ABB industrial drives

User's manual
FSO-11 safety functions module

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List of related manuals

Drive hardware manuals and guides	Code (English)
ACS880-01 hardware manual	*3AUA0000078093*
ACS880-01 quick installation guide for frames R1 to R3	*3AUA0000085966*
ACS880-01 quick installation guide for frames R4 and R5	*3AUA0000099663*
ACS880-01 quick installation guide for frames R6 to R9	*3AUA0000099689*
ACS880-04 hardware manual	*3AUA0000128301*
ACS880-07 hardware manual	*3AUA0000105718*
ACS880-104 inverter modules hardware manual	*3AUA0000105718*
ACS880-107 inverter units hardware manual	*3AUA0000102519*
BCU-02/12/22 control units hardware manual	*3AUA0000113605*
ACS-AP-x assistant control panels user's manual	*3AUA0000085685*

Drive firmware manuals and guides	
ACS880 primary control program firmware manual	*3AUA0000085967*
Quick start-up guide for ACS880 drives with primary control program	*3AUA0000098062*

General safety manuals and guides	
Functional safety; Technical guide No. 10	*3AUA0000048753*
Safety and functional safety; A general guide	*1SFC001008B0201*

Option manuals	
FSO-11 safety function module user's manual	*3AUA0000097054*

Tool manuals	
Drive composer start-up and maintenance PC tool user's manual	*3AUA0000094606*

You can find manuals and other product documents in PDF format on the Internet. See section *Document library on the Internet* on the inside of the back cover. For manuals not available in the Document library, contact your local ABB representative.

User’s manual

FSO-11 safety functions module

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1

Safety

Contents of this chapter

This chapter explains the usage of warnings in this manual.

Use of warnings

Warnings caution you about conditions which can result in serious injury or death and/or damage to the equipment, and advise on how to avoid the danger. The following warning symbols are used in this manual:

Electricity warning warns of hazards from electricity which can cause physical injury and/or damage to the equipment.

General warning warns about conditions, other than those caused by electricity, which can result in physical injury and/or damage to the equipment.

2

Introduction to the manual

Contents of this chapter

This chapter states exclusion of liability and describes the applicability, compatible products, supported safety functions, target audience and purpose of the manual.

The chapter also lists contents of this manual, recommended reading as well as related standards and directives, and explains used definitions, terms and abbreviations. The safety certificate is included at the end of the chapter.

Exclusion of liability

This manual is an informative aid only. It contains information needed to use the FSO-11 safety functions module when implementing safety systems. The information and examples given are for general use only. They do not describe all the necessary details for implementing a safety system. The manufacturer of the machinery always remains ultimately responsible for the product safety and compliance with applicable laws. ABB does not accept any liability for direct or indirect injury or damage caused by the information contained in this document. ABB hereby disclaims all liabilities that may result from this document.

The FSO-11 module must not be opened, otherwise the safety classification will become invalid and the warranty cease to be in effect.

Applicability

This manual applies to the FSO-11 safety functions module, firmware version 1.0 and later, until the next revision of the manual is published.

Compatible products

Drives

- ACS880 series

Tools

- Drive composer pro PC tool.

Supported safety functions

This manual provides instructions for creating the following safety functions (according to EN 61800-5-2:2007) for the ACS880 drives:

- Safe torque off (STO) – standard feature in ACS880 drives, see page *40*
- Safe brake control (SBC), see page *42*
- Safe stop 1 (SS1), without encoder only, see page *46*
- Safe stop emergency (SSE), see page *50*
- Safely limited speed (SLS), without encoder only, see page *55*
- Safe maximum speed (SMS), see page *57*.

Note: The FSO-11 does not support encoder or safe fieldbus in safety applications.

Target audience

The manual is intended for qualified persons who design the safety application, plan the installation as well as install and commission the safety application. Read the manual before starting work on the safety application. The reader is expected to know the fundamentals of safety technology, electricity, wiring, electrical components and electrical schematic symbols.

Purpose of the manual

The manual explains how to install the FSO-11 safety functions module and configure and commission the supported safety functions. It describes how to meet and maintain safety life cycle requirements of the FSO-11 to ensure required safety performance and specified safety integrity.

Drive-specific technical, configuration and installation details are found in the drive *Hardware manual* (see *List of related manuals* on page *2*).

Contents

Chapter *Safety* (page *11*) explains the usage of warnings in this manual.

Chapter *Introduction to the manual* (this chapter, page *13*) states exclusion of liability and describes the applicability, compatible products, supported safety functions, target audience and purpose of the manual.

It also lists contents of this manual, recommended reading as well as related standards and directives, and explains used definitions, terms and abbreviations. The safety certificate is included at the end of the chapter.

Chapter *Safety information and considerations* (page *21*) contains general safety considerations and information to be taken into account when applying the FSO-11 safety functions.

Chapter *Overview* (page *27*) briefly describes the FSO-11 with safety system components as well as the FSO-11 layout, connections, type designation label and operational characteristics.

Chapter *Implemented safety functions* (page *33*) describes how the safety functions are implemented with the drive and how they operate.

Chapter *Planning for installation* (page *59*) gives instructions and references to instructions in other manuals for planning the safety system installation, as well as the requirements for installation in the applicable safety standards.

Chapter *Installation* (page *65*) gives examples of how to connect the FSO-11 module to the ACS880.

Chapter *Installation checklists* (page *71*) contains a checklist for checking the mechanical and electrical installation of the FSO-11 module and refers to common cause failure checklists in standards.

Chapter *Configuration* (page *73*) describes the password usage, outlines the configuration process, lists the FSO-11 parameters and gives examples of how to configure the FSO-11 to implement each safety function as described in chapter *Implemented safety functions*.

Chapter *Start-up* (page *131*) describes the general precautions to be taken before starting up the safety system for the first time.

Chapter *Verification and validation* (page *133*) describes verification and validation of the implemented safety functionality.

Chapter *Fault tracing* (page *143*) describes the status LEDs and provides generic diagnostics and troubleshooting tips for FSO-11 related faults generated by the drive.

Chapter *Maintenance* (page *147*) explains replacement of the FSO-11 module in case of a module failure, reinstalling the FSO-11 module to another drive, updating the firmware of the drive where the FSO-11 is installed, factory reset, FSO-11 update and decommissioning as well as proof tests.

Chapter *Technical data* (page *151*) contains the technical specifications of the FSO-11, for example electrical data, sizes and safety data.

Chapter *Dimension drawings* (page *159*) shows dimension drawings of the FSO-11 module.

Recommended reading

This manual is based on the following standards. It is recommend that one is familiar with these standards before implementing safety-related systems.

- EN 61800-5-2:2007, *Adjustable speed electrical power drive systems – Part 5-2: Safety requirements – Functional*. (Includes safety function definitions.)
- EN ISO 13849-1:2008, *Safety of machinery – Safety-related parts of control systems – Part 1: General principles for design*
- EN 62061:2005, *Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems*
- EN 60204-1:2006, *Safety of machinery – Electrical equipment of machines – Part 1: General requirements*.

Before starting the implementation of safety-related systems, it is highly recommended to read and understand the following manuals, which will also be referred to in the later chapters of this manual.

- *Functional safety; Technical guide No. 10* (3AUA0000048753 [English])
- *Safety and functional safety; A general guide* (1SFC001008B0201 [English])
- *Firmware manual* of the drive.

Related standards and directives

Referenced standards are listed in the table below.

Standard	Name
EN 60204-1:2006	*Safety of machinery – Electrical equipment of machines – Part 1: General requirements*
IEC 61508 Parts 1-7, Ed. 2.0:2010	*Functional safety of electrical/electronic/programmable electronic safety-related systems*
EN 61800-5-2:2007	*Adjustable speed electrical power drive systems – Part 5-2: Safety requirements – Functional*
EN 62061:2005	*Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems*
EN ISO 12100:2010	*Safety of machinery – General principles for design – Risk assessment and risk reduction*
EN ISO 13849-1:2008	*Safety of machinery – Safety-related parts of control systems – Part 1: General principles for design*. EN ISO 13849-1 has replaced EN 954-1:1996 in November 2009.
2006/42/EC	*European Machinery Directive*

Standard	Name
Other	Sector-specific C-type standards

Definitions

Safety-related definitions according to EN ISO 13849-1:2008, EN 62061:2005 and EN 61800-5-2:2007 are presented in the table below.

Term	Definition
Acknowledgement	Acknowledges an event when the FSO-11 is in use. See section *Acknowledgement* on page *34*. See also term *Reset* on page *17*.
Common cause failure (CCF)	Failure, which is the result of one or more events, causing coincident failures of two or more separate channels in a multiple channel (redundant architecture) subsystem, leading to failure of a Safety related electronic control function (SRCF)
Functional safety	Part of the safety of the machine and the machine control system which depends on the correct functioning of the SRECS, other technology safety-related systems and external risk reduction facilities
Hazard	Potential source of harm (physical injury, or damage to health or equipment)
Power drive systems (Safety related), PDS(SR)	Adjustable speed electrical power drive system suitable for use in safety-related applications
Proof test	Test that can detect faults and degradation in a Safety related electronic control system (SRECS) and its subsystems so that, if necessary, the SRECS and its subsystems can be restored to an "as new" condition or as close as practical to this condition.
Protective measure	Measure intended to achieve risk reduction
Reasonably foreseeable misuse	Use of a machine in a way not intended by the designer, but which may result from readily predictable human behavior
Reset	Factory reset. Clears the configuration and sets the parameters to their factory default values.
Residual risk	Risk remaining after protective measures have been taken
Response time of FSO-11	The internal response time of the FSO-11, that is the time in which the STO control output of the FSO-11 reacts after receiving a request. Usually this is not the same as the time from the request to the safe state of the machine application. See also term *Safety function response time* on page *17*.
Risk	Combination of the probability of occurrence of harm and the severity of that harm
Safe state	STO activated (STO relay opened)
Safety function response time	Response time of the combination of the drive and FSO-11. See also term *Response time of FSO-11* on page *17*.

Term	Definition
Safety related control function (SRCF)	Control function implemented by a SRECS with a specified integrity level that is intended to maintain the safe condition of the machine or prevent an immediate increase of the risk(s)
Safety related electrical control system (SRECS)	Electrical control system of a machine whose failure can result in an immediate increase of the risk(s)
Stop category	There are three categories of stop functions: • stop category 0: an uncontrolled stop where power to the machine actuators is removed immediately • stop category 1: a controlled stop where the machine actuators have power for stopping, after which the power is removed • stop category 2: a controlled stop where the machine actuators continue to have power. Category 0 and 1 definitions also apply to Emergency stop categories.
Validation	Confirmation by, for example, analysis that the safety system meets the functional safety requirements of the specific application
Verification	Confirmation by, for example, testing that the safety system meets the requirements set by the specification
Zero speed	Speed below the value given with parameter *163 Zero speed without encoder* on page *87*.

Terms

The following terms are used in this manual as defined in the table below.

Term	Definition
External active load	Load in systems where the motor speed does not decrease when the motor control is stopped.
Life time	The period of time for which a device is designed to remain within it's specifications
Safety function	Function, with a specified safety performance, which is intended to maintain the safe condition of the installation or prevent hazardous conditions arising at the installation. Example: Safe torque off (STO)
Safety module	Part of a safety system, physical entity. Example: FSO-11 safety functions module.
Safety system	Whole safety system including for example human interface, FSO-11 safety functions module, drive and sensors.

Abbreviations

Safety related

This manual uses abbreviations for safety levels as defined in the table below.

Abbreviation	Reference	Description
B_{10d}	EN ISO 13849-1	Number of cycles until 10% of the components fail dangerously (for pneumatic and electromechanical components).
CCF	EN ISO 13849-1	Common cause failure
DC	EN ISO 13849-1	Diagnostic coverage (%)
FIT	IEC 61508	Failure in time: 1E-9 hours. Expected failure rate of semiconductors and other electronic devices.
HFT	IEC 61508	Hardware fault tolerance
$MTTF_d$	EN ISO 13849-1	Mean time to dangerous failure: (The total number of life units) / (the number of dangerous, undetected failures) during a particular measurement interval under stated conditions
PFD	IEC 61508	Probability of failure on demand
PFH_d	IEC 61508	Probability of dangerous failures per hour
PL	EN ISO 13849-1	Performance level (a-e)
SFF	IEC 61508	Safe failure fraction (%)
SIL	IEC 61508	Safety integrity level (1-3)
STO	EN 61800-5-2	Safe torque off
T1	IEC 61508	Proof test interval

Other

This manual uses other than safety related abbreviations as defined in the table below.

Abbreviation	Description
AWG	American wire gauge
CRC	Cyclic redundancy check
ELV	Extra-low voltage
I/O	Input/output
PCB	Printed circuit board
PELV	Protected extra-low voltage (IEC 60364-4-41)
ZCU-11	A control unit type used by ACS880

Certificate

TÜV NORD certificate is attached below.

TÜV NORD

Certificate

No. SLA-0131/2009, Ver. 1.0

TÜV NORD Systems GmbH & Co. KG hereby certifies

ABB Oy
Hiomotie 13
FI-00381 Helsinki
Finland

that the safety functions module

FSO-11

as a plug-in module for the ABB industrial drive ACS880 series

is developed according to the following standards:

- IEC 61508 part 1, part 2, part 3: 2010; capable up to SIL 3
- IEC 61800-5-2: 2007; capable up to SIL 3
- ISO 13849 part 1: 2006, part 2: 2003; capable up to PL e (category 3)
- IEC 62061: 2005; capable up to SIL_{CL} 3

Beneath the integrated "Safe Torque Off (STO)" function within the industrial drive ACS880 series (see certificate No. SLA-0055/10), the additional safety functions "Safely Limited Speed (SLS)", "Safe Maximum Speed (SMS)", "Safe Stop Emergency (SSE)", "Safe Stop 1 (SS1)" and "Safe Brake Control (SBC)" can be realized with the plug-in safety functions module FSO-11.

The whole assembly can be used in safety applications up to SIL 3 according to IEC 61511. The released versions of the certified FSO-11 are given in the "tracking-list for released versions of the FSO-11". This list is an add-on to this certificate.

The certification is based on the report No. SLA-0131/2009TB-3 in the valid version.

This certificate entitles the holder to use the pictured Safety Approved mark.

Expiry date: 2017-09-21
Reference No.: G.SEB.BS.02.021.03.031

Augsburg, 2012-09-21

Gerhard M. Rieger

Voluntary Certification

TÜV NORD
TÜV NORD Systems GmbH & Co. KG
Safety Approved
FSO-11
IEC 61508 SIL 3
IEC 61800-5-2 SIL 3
ISO 13849 PL e
IEC 62061 SIL_{CL} 3
SLA-0131/2009 V1.0

TÜV NORD Systems GmbH & Co. KG, Branch South, Halderstr. 27, 86150 Augsburg, Germany

3

Safety information and considerations

Contents of this chapter

This chapter contains general safety considerations and information to be taken into account when applying the FSO-11 safety functions.

WARNING! The FSO-11 safety functions module is delivered with the safety functions bypassed by jumper wires in connectors X:113 and X:114 to allow initial drive commissioning without the need to configure safety functions first. The safety system must always be properly commissioned and verified/validated before it can be considered safe.

Meeting the requirements of the Machinery Directive

In order to fulfill the requirements of the Machine directive, the requirements in the applicable standards must be met and the FSO-11 must be used according to all instructions provided in this manual.

Implementing safety functions requires following a process, which is introduced for example in *Functional safety; Technical guide No. 10* (3AUA0000048753 [English]). The process includes a risk assessment, and residual risks, as well as any foreseeable misuse, must be documented in the user instructions of the machinery.

Responsibilities

It is the responsibility of the machine builder / OEM / system integrator to ensure that the essential health and safety requirements specified in the Machinery Directive are met.

If you detect any failure in safety functions, contact your local ABB representative.

Safety considerations

Note: After you initially start-up the FSO-11 and also after you later modify any application parameters or the configuration, you must check the safety of the entire system by doing a verification according to the system safety verification plan and by doing a validation of the correct operation of the safety application. See *Verification and validation* on page *133*.

Response times

Safety function response time and FSO-11 response times are specified in section *Response times* on page *158*.

FSO-11 diagnostics

The FSO-11 performs extensive auto diagnostics tests during the runtime operation on FSO-11 internal parts as well as the communication and STO connection between the FSO-11 and the drive, and it will go into the Fault state if it detects a fault. If the safety functions are still in control, the SSE is activated, otherwise the STO is activated.

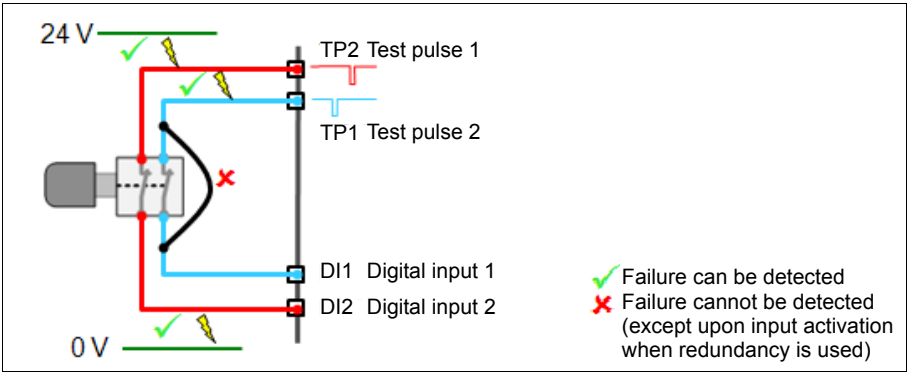
- The communication between the FSO-11 and the drive is diagnosed continuously.
- The STO connection between the FSO-11 and the drive STO connector is diagnosed during the power up and periodically during the runtime.

I/O

The FSO-11 supports input and output redundancy.

The FSO-11 provides an option for applying diagnostic pulsing for its inputs and outputs. When applied, the pulsing enables the FSO-11 diagnostics to detect cable failures as follows:

- Inputs: Open-circuiting and short-circuiting failures are detected, with the exception of failures that short-circuit the sensor. These failures are detected upon input activation when redundant connection is used.


24 V
TP2 Test pulse 1
TP1 Test pulse 2
DI1 Digital input 1
DI2 Digital input 2
0 V
Failure can be detected
Failure cannot be detected (except upon input activation when redundancy is used)

- Outputs: Failures that short-circuit the signal to the voltage supply or the ground potential are detected. Failures that open-circuit the actuator are not detected.

Safety function acknowledgement modes

Safety functions have two acknowledgement modes for entering the Operational state (during the first start-up or after a safety function request is removed):

- **Monitored:** In the monitored (manual) restart (recommended), the user must first acknowledge the FSO-11 state to allow the drive to restart.
- **Automatic:** In the automatic restart, the FSO-11 grants the drive permission to restart after a safety function request is removed or the start-up is complete. If the drive is in the automatic start mode, it starts automatically, which may cause danger.

The acknowledgement mode can be selected separately for the start-up, STO (SSE and SS1 always end in STO) and SLS.

Note: STO, SSE and SS1 cannot be acknowledged before the motor is stopped.

Note: The FSO-11 is not designed to protect a machine against intentional misuse.

WARNING! If the FSO-11 is used in the automatic mode, make sure that the system is designed so that this does not cause unacceptable risk.

Encoderless mode

Note: The FSO-11 uses drive output frequency measurement to estimate the motor speed instead of measuring the motor speed with an encoder. This has to be taken into consideration when designing safety functions, that is, whether this type of speed estimation is suitable for the application.

Note: Observe restrictions for use. At least normal Identification run, preferably full Identification run must be performed.

In the encoderless mode,

- the motor must decelerate when the power is switched off – for example, in a crane application, the hanging load would potentially cause an accelerating motion, thus the encoderless mode, and thereby the FSO-11, cannot be used for these types of applications.
- the drive cannot be used in generator mode (torque limit) operation where an external force is rotating the motor faster than the drive controls the motor.
- the system must be designed so that it has no physical capability of accelerating/decelerating from an acceptable speed to a dangerous speed within the response time of the FSO-11 (see section *Safety data* on page *155*).
- depending on the load, the frequency estimation of an encoderless drive may not be equal to the actual induction motor speed.

WARNING! Do not use encoderless mode in applications when the external load of the application may rotate the motor driven shaft in spite of the drive frequency. In this case, an encoder and encoder supporting version of the FSO must be used to measure and monitor the shaft speed.

Speed estimation

The FSO-11 monitors the frequency with which the drive is rotating the magnetic field in the motor because the FSO-11 has no way of detecting the actual speed with which the motor shaft is rotating.

Note: “Speed” is used in this manual instead of “frequency”.

Note: It must be taken into account in the system design that the FSO-11 estimation and the actual motor speed differ by the slip, which is dependent on the load of the motor among other things.

Characteristics

The allowed speed range depends on the used motor.

$$\text{Max. speed range} = \frac{\text{-18000…+18000 rpm}}{\text{Number of motor pole pairs}}$$

Proof testing

Periodic proof testing of for example electromechanical parts of the safety system may be required in order to maintain the claimed SIL / PL level of the system. In this case proof testing must be taken in to consideration in the safety calculations and it must be properly documented in the user documentation. Proof testing has to be verified in the acceptance testing during the commissioning phase.

The FSO-11 module itself does not require periodic proof testing.

External contactors, relays and mechanical actuators must be sized correctly for safety use as the automatic diagnostics only monitor the electrical connections; the mechanical final elements like brakes are not diagnosed.

Failure of a mechanical actuator, for example a brake, could lead up to an undetected fault, and a possible loss of the load control.

Safety separation

The FSO-11 and the drive Safe torque off (STO) channel/function are safety relevant, and the rest of the drive is considered as not safety relevant, for example the drive regular I/O cannot be used for requesting safety functions on the FSO-11.

⚠ **WARNING!** The Safe torque off function does not disconnect the voltage of the main and auxiliary circuits from the drive. Therefore maintenance work on electrical parts of the drive or the motor can only be carried out after isolating the drive system from the main supply, from the rotating permanent magnet motors and from the rotating motors equipped with sinus filters; asserting the STO is not sufficient.

Note: The Safe torque off function can be used for stopping the drive in the operational mode. If a running drive is stopped by using the STO function, the drive will stop by coasting.

4

Overview

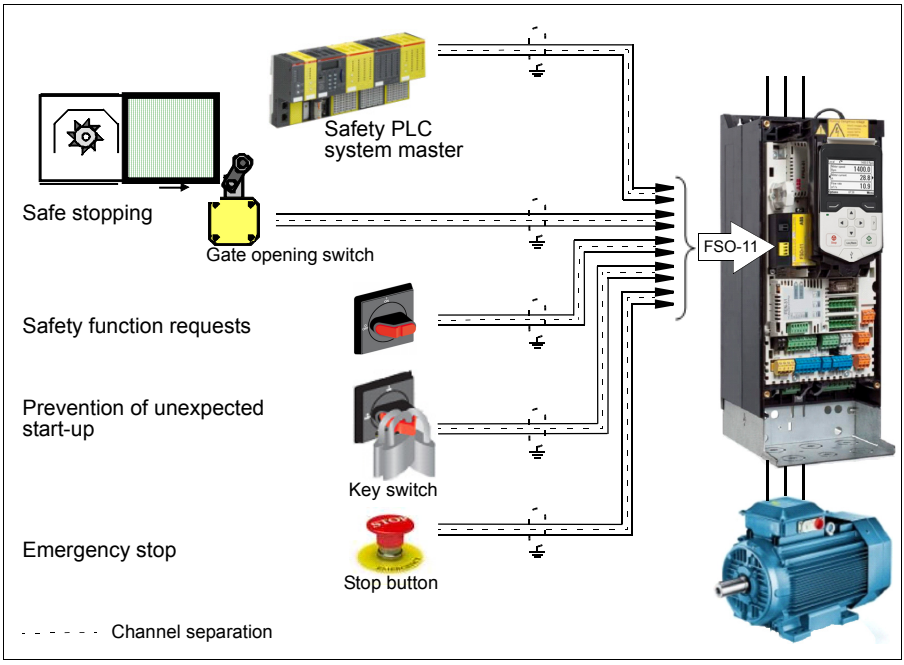
Contents of this chapter

This chapter briefly describes the FSO-11 with safety system components as well as the FSO-11 layout, connections, type designation label and operational characteristics.

System description

FSO-11 and safety system components

Example figure of an FSO-11 safety functions module, ACS880 drive, safety PLC, switches and buttons.

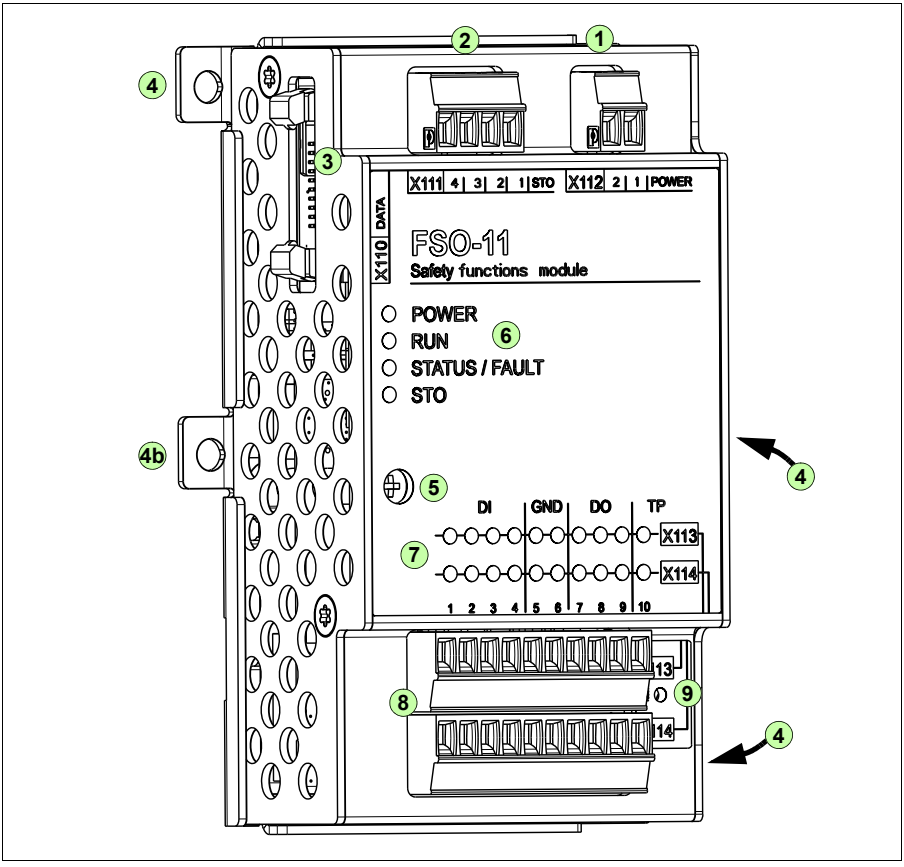


The FSO-11 safety functions module is an option for ACS880 drives. Safe torque off (STO) is a standard feature on ACS880 drives.

The FSO-11 does not operate the drive; it only monitors the actions of the drive and commands safety functions to be executed. The request for safety functions can come from an external safety system, for example a push button, safety PLC, or from the FSO-11 internal fault. If the drive does not fulfill the commands of the FSO-11, the FSO-11 will shut down the drive using the Safe torque off (STO) function.

Safety functions supported by the FSO-11 are presented in chapter *Implemented safety functions* on page 33.

Layout



No	Description
1	24 V DC input connection
2	Safe torque off (STO) connection
3	Data connection
4, 4b	Mounting for drives with ZCU-11 control unit shown. Two mounting points on each side. The screw fixed at 4b also grounds the enclosure of the FSO-11. Mounting points for drives with other control units may vary.
5	FSO-11 grounding screw, grounds the electronics
6	FSO-11 status LEDs, see section *Status LEDs* on page *143*.
7	Input / output status LEDs, one for each I/O connector (see *8*). The LEDs are in two rows above the corresponding two rows of I/O connectors. The LED is lit if the state of the corresponding I/O is ON (24 V in the input or output). The data shown by LEDs is only indicative and cannot be considered safe.

No	Description
8	Input / output connections • 4 redundant or 8 single digital inputs, or combinations of redundant and single inputs. Possible redundant pairs: X113:1 & X114:1, X113:2 & X114:2, X113:3 & X114:3 and X113:4 & X114:4. • 3 redundant or 6 single digital outputs, or combinations of redundant and single outputs. Possible redundant pairs: X113:7 & X114:7, X113:8 & X114:8 and X113:9 & X114:9. • two 24 V DC reference outputs with configurable diagnostic pulses.
9	Factory reset button (under the label)

Connections

The FSO-11 has several safety I/O's for external safety devices, for example buttons, gates and indicators. FSO-11 does not have ability to interface to an encoder.

When using the Safe brake control (SBC) function, the mechanical brake is controlled by the FSO-11. For more information on the SBC, see section *Safe brake control (SBC)* on page *42*.

One FSO-11 is needed for each drive/inverter to be monitored.

Connection details are described in section *Terminals* on page *67*.

Type designation label

The type designation label is attached on the top of the FSO-11 module. An example label and explanation of the label contents are shown below.

No	Description
1	Type
2	Serial number of format MYYWWRXXXX, where M: Manufacturer YY: 11, 12, … for 2011, 2012, … WW: 01, 02, 03, … for week 1, week 2, week 3, … R: A, B, C, … for product revision number XXXX: Integer starting every week from 0001
3	ABB MRP code of the FSO-11 module
4	Combined ABB MRP code and serial number
5	RoHS mark

Operational characteristics

The FSO-11 monitors that the drive operates within the configured operating limits, and if the limits are exceeded, activates the STO function within the response time. Activation of the STO function removes the torque and, if configured, applies the brake.

WARNING! The Safe torque off function does not disconnect the voltage of the main and auxiliary circuits from the drive. See the warning on page *25*.

Prevention of unexpected start-up is also handled by the FSO-11.

The supported functions are preprogrammed in the firmware; they cannot be programmed in any way.

Authorized personnel configure the FSO-11 with the Drive composer pro PC tool. The FSO-11 checks the authorization with a password before it is possible to edit the FSO-11 parameters. Parameters are sent from the tool to the drive, and after the tool has displayed the CRC values of the parameters, the user must validate the feedback values.

The FSO-11 goes into the Fault state if it detects an internal fault during its diagnostics tests.

5

Implemented safety functions

Contents of this chapter

This chapter describes how the safety functions are implemented with the drive and how they operate.

Safety functions

The FSO-11 supports the following safety functions:

Safety function	Stop category	Information	Page
Safe torque off (STO)	Stop category 0	Drive feature	*40*
Safe brake control (SBC)		Safe brake output	*42*
Safe stop 1 (SS1)	Stop category 1	Also with ramp monitoring	*46*
Safe stop emergency (SSE)		Configurable as STO or SS1 with E-Stop ramp	*50*
Safely-limited speed (SLS)		Safely limited speed	*55*
Safe maximum speed (SMS)		Function permanently on/off	*57*

General

Acknowledgement

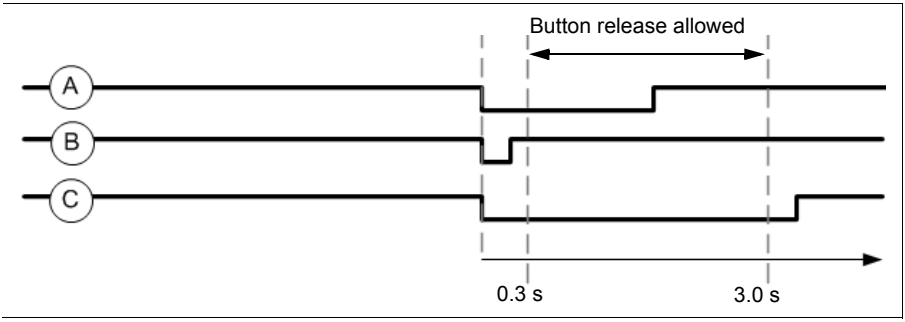
Acknowledgement can be configured to be manual or automatic, separately for the start-up, STO (SSE and SS1 always end in STO) and SLS. In manual acknowledgement there must be an acknowledgement button connected to the FSO-11. In automatic acknowledgement the FSO-11 automatically acknowledges the start-up, STO or SLS when this has completed successfully.

Acknowledgement cannot be performed if

- safety function request is active
- STO, SSE, SS1: safety function is not completed
- SLS: speed is not below monitored limit.

All active safety functions that can be acknowledged are acknowledged with the same acknowledgement.

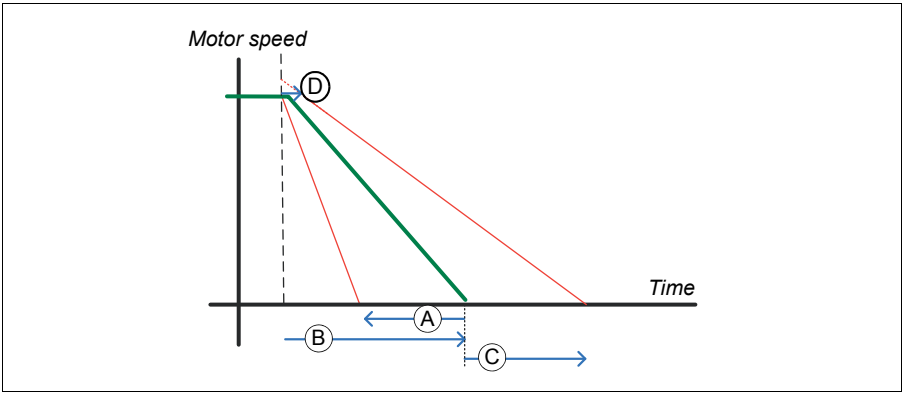
The acknowledgement button is connected like a normal safety input. 24 V in the input is the standby (negative) state and 0 V is the positive (acknowledge) state.



ID	Description
A	Normal acknowledgement: The acknowledgement is recognized when the button is released after pressing it; the system must detect both falling and rising edge changes for successful acknowledgement triggering. The pressing time of the button must be between 0.3 s…3.0 s.
B	Short low signals (less than 300 ms) are ignored.
C	Too long interruptions (signal low longer than 3 s) on the signal are ignored and a warning message is generated to the drive. If there is something to acknowledge, it is ignored and the user must press the acknowledgement button again. If there is nothing to acknowledge, nothing happens and no errors are generated.

Ramp monitoring

The ramp monitoring is configured with four parameters as described below.



ID	Description
A	Ramp minimum time from the scaling speed to the zero speed = B - A. Specified for each SARn ramp, n = 0…1 separately. For example for SAR0: parameter *104 SAR0 min ramp time to zero*.
B	Target time for the ramp down from the scaling speed to the zero speed. Specified for each SARn ramp, n = 0…1 separately. For example for SAR0: parameter *103 SAR0 ramp time to zero*.
C	Ramp maximum time from the scaling speed to the zero speed = B + C. Specified for each SARn ramp, n = 0…1 separately. For example for SAR0: parameter *105 SAR0 max ramp time to zero*.
D	Initial allowed range for the SARn ramp. This is the time when the monitoring of the ramp maximum time is started after the request. Common for all ramps SARn, n = 0…1. Parameter *127 SAR initial allowed range*.

Note: Maximum allowed time for a ramp is ten minutes from 1500 rpm to the zero speed.

Function indication

The logic state of the output indication can be configured to be active low or active high.

STO, SS1, SSE:

States of the configured and connected functions are indicated with FSO-11 digital outputs when the function is started:

- Stopping functions are always started immediately (first they monitor the time, then possibly the ramp).
- STO is indicated right away when the request is active (requested from input or by diagnostics).
- Ramp monitoring (SAR0 and SAR1, see section *Configuring SAR* on page *123*) is not indicated.

Digital output indication is removed when the function is completed.

- SSE and SS1 are completed when the STO is acknowledged.

Stopping indication is activated when the stopping function has completed, but is not yet acknowledged. There are separate indications for each stopping function STO, SSE and SS1 (parameters *21 STO completed output*, *31 SSE completed output* and *40 SS1 completed output*) and one common for all of them (parameter *6 Stop completed output*).

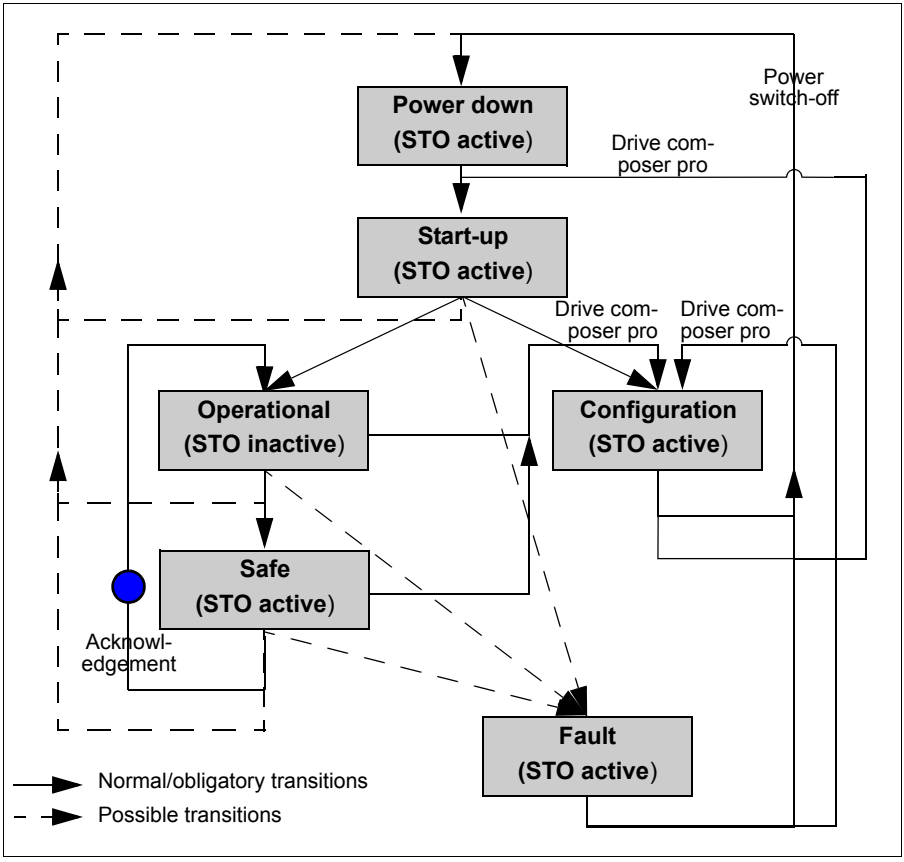
SLS:

- SLS indication starts when the speed is in the monitored range, and indication is removed when the function is completed or the monitored speed limit is exceeded (this also causes the SLS to trip, that is, SSE is activated).

States

The FSO-11 can be in one of the following states:

- Power down: STO active, power off (below 19 V)
- Start-up: STO active, power on (above 19 V), start-up checks performed
- Configuration: STO active, setting of parameters
- Operational: STO inactive, FSO-11 running
- Safe: STO active, FSO-11 running
- Fault: STO active, FSO-11 or communication fault detected.



At power-up, the FSO-11 goes into the Start-up state; it performs start-up checks and, according to the configuration, enters the Operational state either automatically or after a manual acknowledgement.

The Drive composer pro PC tool can request the Configuration state, when the FSO-11 is in the Start-up, Operational, Safe or Fault state and the drive is in the Torque off mode (not modulating). The FSO-11 exits the Configuration state into the Start-up state either by a request from the Drive composer pro PC tool, or by removing the power from the FSO-11 (through the Power down state).

In the Operational and Safe states, the FSO-11 can execute the safety functions.

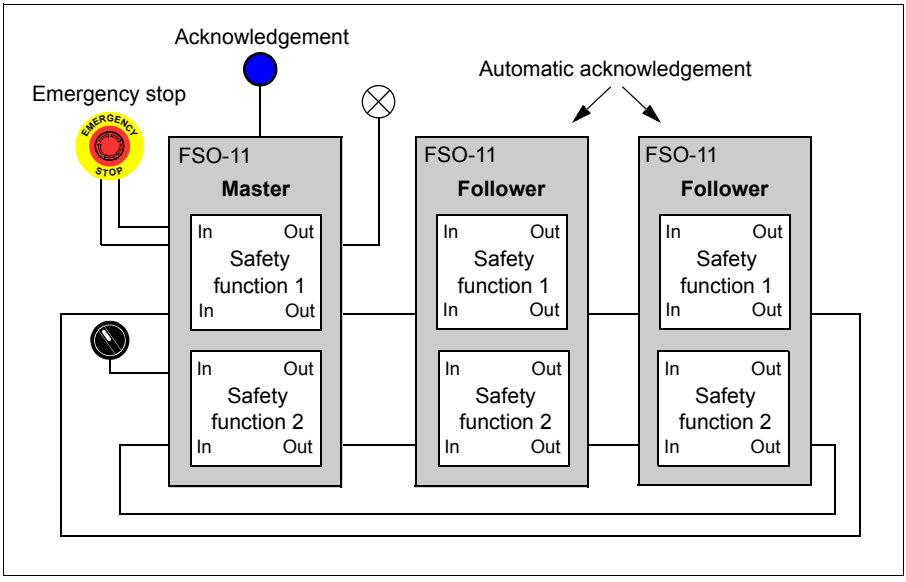
Note: When the FSO-11 is in the Configuration state, the status/fault LED is lit red. This requires the FSO-11 power down cycle to take the new parameters into use before entering the Operational state.

If there is an internal fault, the FSO-11 enters the Fault state. The FSO-11 exits the Fault state either by a request from the Drive composer pro PC tool into the Configuration state, or by removing the power from the FSO-11 into the Power down state. In the latter case, the FSO-11 starts again normally from the Start-up state after restoring power.

When the FSO-11 is in the Power down, Start-up, Configuration, Safe or Fault state, the STO is always active. When the FSO-11 is in the Operational state, the STO is inactive.

Cascade

It is possible to cascade up to six FSO-11's into a daisy-chain type network (resembles somewhat an I/O master-follower system): If an FSO-11 triggers a cascaded function, it passes the triggering information to the next FSO-11, which triggers the next one, and so on, until the last FSO-11 again triggers the first one.



Cascade I/O connections must be set to use diagnostic pulsing.

One of the cascaded FSO-11’s must be configured as a master and the others as followers.

All of the cascaded FSO-11’s must be set to use automatic acknowledgement. The master may have an acknowledgement button, and the acknowledgement always starts from the master.

Up to two safety functions may be cascaded, but it is highly recommended that one of them is either SSE or STO.

If an FSO-11 activates STO for any reason, also the cascaded SSE output is triggered.

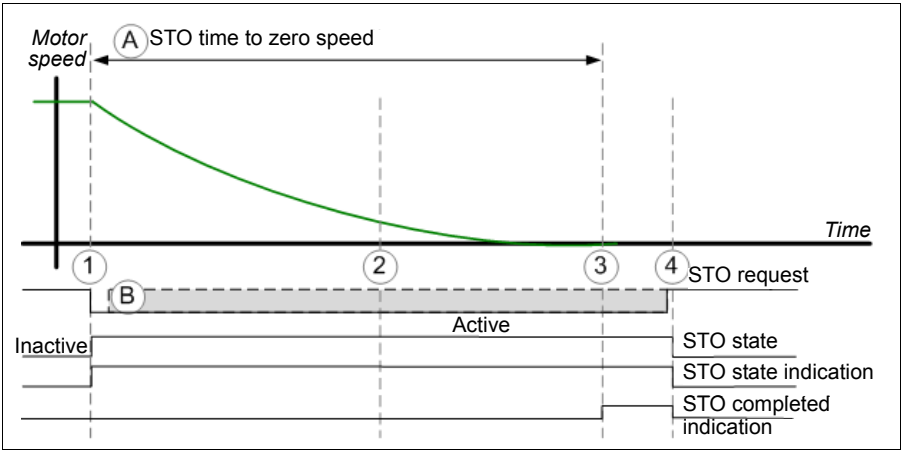
Safe torque off (STO)

STO base function

The STO brings the machine safely into a no-torque state and/or prevents it from starting accidentally.

For more information on the STO base function in ACS880 drives, see the drive *Firmware manual*.

The operation of the STO function is described in the time diagram and table below.



ID	Description
A	Time to zero speed: Time from the STO activation to the moment when the acknowledgment becomes allowed. Configured to the estimated time in which the motor coasts to a stop from the maximum speed.
B	STO request removal allowed (shaded area). The STO request must be active for at least 10 ms. The STO request must be removed before the acknowledgement is accepted.
1	STO activated after the STO request has been received (for example from the I/O)
2	Acknowledgement is not allowed before the motor is presumably stopped.
3	After the time to zero speed (A) has elapsed, the STO is completed and the acknowledgement is possible as soon as the STO request has been removed.
4	After the acknowledgement (manual or automatic), the STO is deactivated.

Note: Logic states of the STO state indication and STO completed indication signals (outputs) are configurable.

Note: STO activation also activates the SSE state indication signal (output), if the SSE is cascaded. See *Safe stop emergency (SSE)* on page *50* and *Cascade* on page *38*.

For configuration, see section *How to configure STO* on page *103* in chapter *Configuration*.

Safe brake control (SBC)

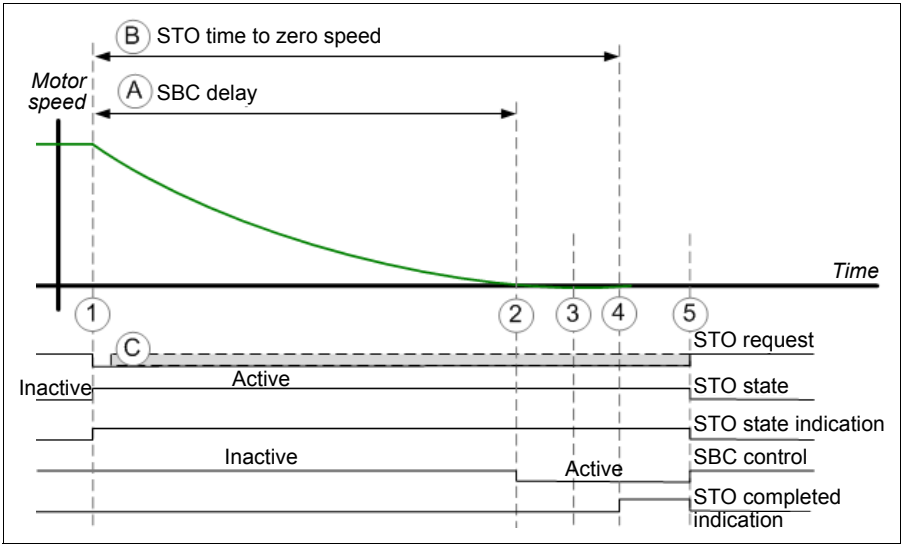
The SBC provides a safe output for controlling external (mechanical) brakes.

If the SBC is used, it is always combined with the STO, except in drive proof testing.

The SBC can be configured to be activated before, at the same time with, or after the STO. The SBC and STO combination can also be configured to be activated below a certain speed level while ramping down to the zero speed (see *SS1 with speed limit activated SBC* on page *49* and *SSE with speed limit activated SBC* on page *54*). In that case, the SBC is activated at the configured speed level.

SBC after STO

The operation of the SBC after the STO is described in the time diagram and table below.



ID	Description
A	SBC delay: Time from the STO activation to the moment when the mechanical brake is active (on). Configurable.
B	Time to zero speed: Time from the STO activation to the moment when the acknowledgment becomes allowed. Configured to the estimated time in which the motor coasts to a stop from the maximum speed.
C	STO request removal allowed (shaded area). The STO request can be removed after a minimum down time. It must be removed before the acknowledgement is accepted.
1	STO activated after the STO request has been received (for example from the I/O)
2	SBC is activated
3	Acknowledgement is not allowed before the motor is presumably stopped.

ID	Description
4	After the time to zero speed (B) has elapsed, the STO is completed and the acknowledgement is possible as soon as the STO request has been removed.
5	After the acknowledgement (manual or automatic), the STO and SBC are deactivated, and the control is given back to the drive, which controls the brake from now on.

Note: Logic states of the STO state indication and STO completed indication signals (outputs) are configurable.

Note: STO activation also activates the SSE state indication signal (output), if the SSE is cascaded. See *Safe stop emergency (SSE)* on page *50* and *Cascade* on page *38*.

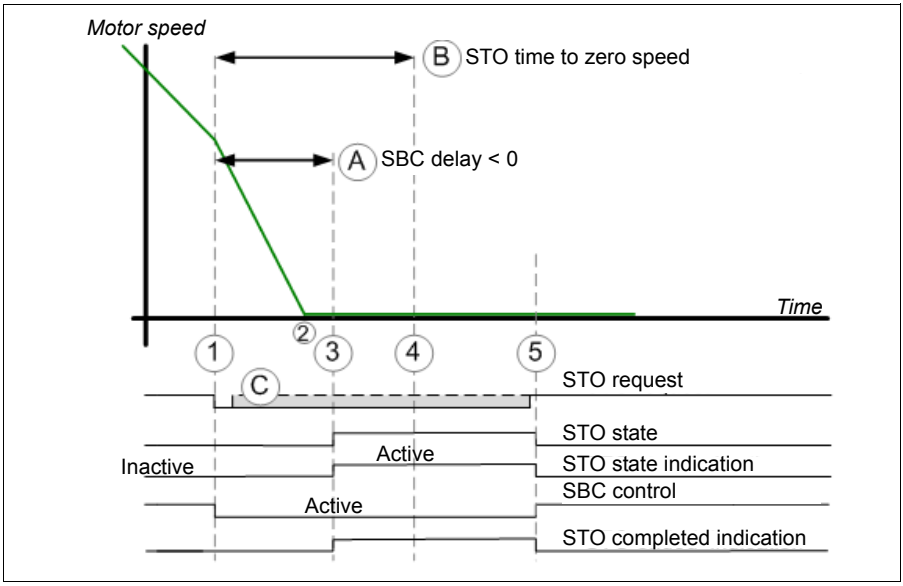
It is possible to set the SBC delay so that the SBC is activated while the motor is still rotating, as in the example above.

For configuration, see section *How to configure SBC after STO* on page *105* in chapter *Configuration*.

SBC before STO

The target of the 'negative' SBC delay is to have the mechanical brake closed just before (or at the same moment as) the STO is opened.

The operation of the SBC before the STO is described in the time diagram and table below.



ID	Description
A	SBC delay: Time from the STO activation to the moment when the mechanical brake is active (on). Value negative.
B	Time to zero speed: Time from the STO activation to the moment when the acknowledgment becomes allowed. Configured to the estimated time in which the motor coasts to a stop from the maximum speed.
C	STO request removal allowed (shaded area). The STO request can be removed after a minimum down time. It must be removed before the acknowledgement is accepted.
1	SBC activated after the STO request has been received (for example from the I/O)
2	Braking has ended and the motor is at a standstill.
3	STO activated after the SBC delay (A) has elapsed.
4	After the time to zero speed (B) has elapsed, the acknowledgement is possible as soon as the STO request has been removed.
5	After the acknowledgement (manual or automatic), the STO and SBC are deactivated, and the control is given back to the drive, which controls the brake from now on.

Note: Logic states of the STO state indication and STO completed indication signals (outputs) are configurable.

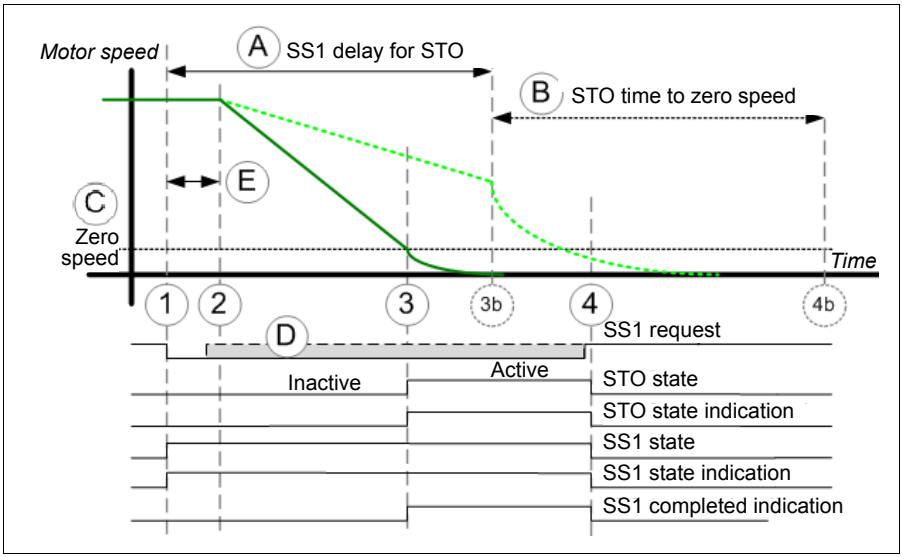
Note: STO activation also activates the SSE state indication signal (output), if the SSE is cascaded. See *Safe stop emergency (SSE)* on page *50* and *Cascade* on page *38*.

For configuration, see section *How to configure SBC before STO* on page *107* in chapter *Configuration*.

Safe stop 1 (SS1)

The SS1 stops the motor safely, initiating the STO function below a specified speed or after a specified time limit.

SS1 with time monitoring



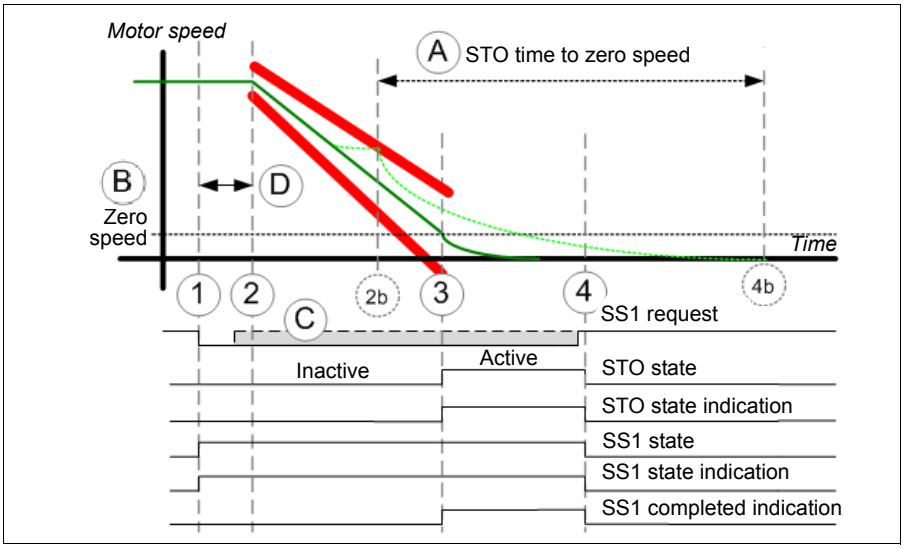
ID	Description
A	SS1 delay for STO: Time after which the STO is activated regardless of the speed.
B	Time to zero speed: Time from the STO activation to the moment when acknowledgment becomes allowed. Configured to the estimated time in which the motor coasts to a stop from the maximum speed. Relevant only if *3b* occurs.
C	Zero speed: Speed limit for activating the STO
D	SS1 request removal allowed (shaded area). The SS1 request can be removed after a minimum down time. It must be removed before the acknowledgement is accepted.
E	Safety function response time
1	SS1 request received (for example from the I/O)
2	After the safety function response time, ramping down is started.
3	Speed goes below the defined zero speed limit, and the STO is activated.
3b	If the drive has not ramped down fast enough when the delay for STO (A) has elapsed, the STO is activated now and the time to zero speed (B) is started.
4	After the acknowledgement (manual or automatic), the STO and SS1 are deactivated.
4b	If the drive had not ramped down fast enough at *3b*, acknowledgement would become allowed now.

Note: Logic states of the STO state indication, SS1 state indication and SS1 completed indication signals (output) are configurable.

Note: SS1 monitoring is started immediately after the SS1 request is received.

For configuration, see section *How to configure SS1 with time monitoring* on page *109* in chapter *Configuration*.

SS1 with ramp monitoring

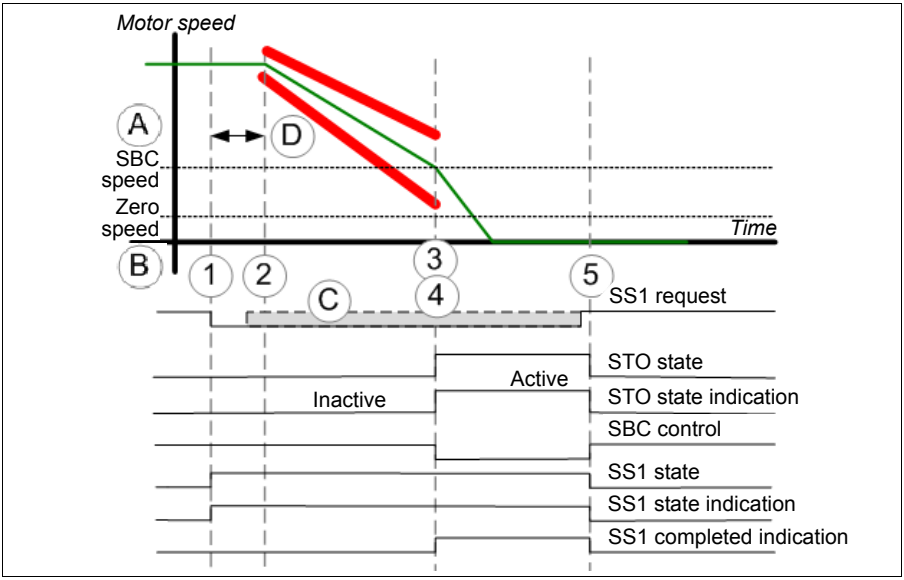


ID	Description
A	Time to zero speed: Time from the STO activation to the moment when the acknowledgment becomes allowed. Configured to the estimated time in which the motor coasts to a stop from the maximum speed. Relevant only if *2b* occurs.
B	Zero speed: Speed limit for activating the STO.
C	SS1 request removal allowed (shaded area). The SS1 request can be removed after a minimum down time. It must be removed before the acknowledgement is accepted.
D	Safety function response time
1	SS1 request received (for example from the I/O)
2	After the safety function response time, ramping down with SAR1 monitoring is started.
2b	If the drive has not followed the ramp, the STO is activated now and the time to zero speed (A) is started.
3	Speed goes below the defined zero limit, the SAR monitoring is stopped and the STO is activated
4	After acknowledgement (manual or automatic), the STO and SS1 are deactivated, and the control is given back to the drive, which is allowed to modulate again.
4b	If the drive had not followed the ramp at *2b*, acknowledgement would become allowed now.

Note: Logic states of the STO state indication, SS1 state indication and SS1 completed indication signals (output) are configurable.

For configuration, see section *How to configure SS1 with ramp monitoring* on page *111* in chapter *Configuration*.

SS1 with speed limit activated SBC



ID.	Description
A	SBC speed: Speed below which the brake is activated while ramping
B	Zero speed: Speed limit for activating the STO
C	SS1 request removal allowed (shaded area). The SS1 request can be removed after a minimum down time. It must be removed before the acknowledgement is accepted.
D	Safety function response time
1	SS1 is requested (for example from the I/O).
2	After the safety function response time, ramping down with SAR0/SAR1 monitoring is started.
3	Speed is below the SBC speed; the SAR monitoring is stopped and the brake is activated
4	STO is activated after brake activation.
5	After acknowledgement (manual or automatic), the STO and the brake are deactivated, and the control is given back to the drive, which is allowed to modulate again.

Note: Logic states of the STO state indication, SS1 state indication and SS1 completed indication signals (output) are configurable.

For configuration, see section *How to configure SS1 with speed limit activated SBC* on page *113* in chapter *Configuration*

Safe stop emergency (SSE)

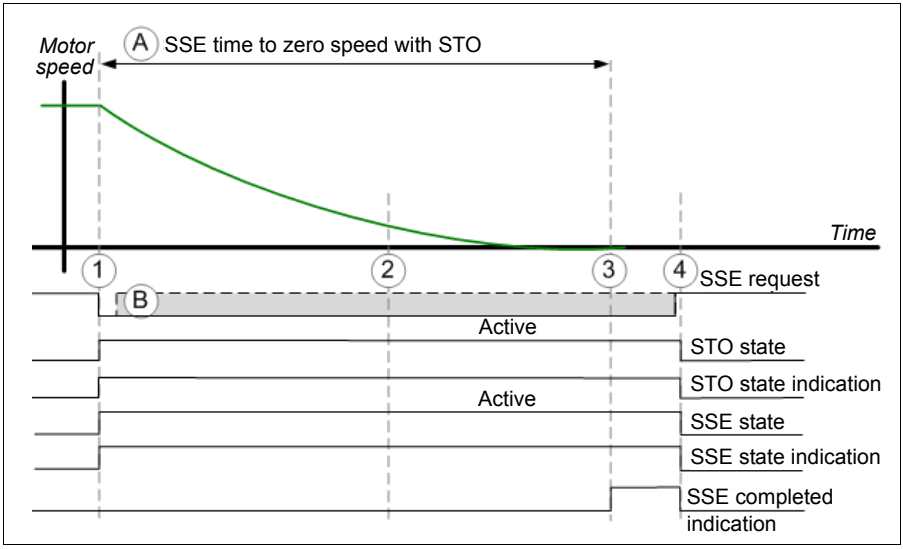
The SSE can be configured to execute either the STO, or the SS1 with emergency ramp.

The behavior of the SSE with STO is identical to the pure STO, except that different timing parameters are used.

The behavior of the SSE with SS1 with emergency ramp is identical to the SS1 with ramp monitoring.

For configuration, see section *How to configure SSE* on page *115* in chapter *Configuration*.

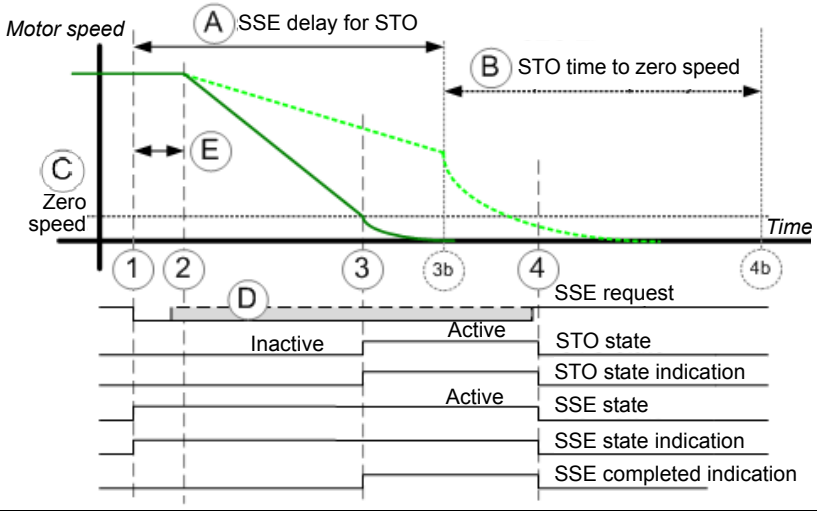
The operation of the SSE function with STO is described in the time diagram and table below.



ID	Description
A	SSE time to zero speed with STO: Time from the STO activation to the moment when the acknowledgment becomes allowed. Configured to the estimated time in which the motor coasts to a stop from the maximum speed.
B	SSE request removal allowed (shaded area). The SSE request can be removed after a minimum down time. It must be removed before the acknowledgement is accepted.
1	STO activated after the SSE request has been received (for example from the I/O).
2	Acknowledgment not yet allowed before the motor is presumably stopped.
3	After the time to zero speed (A) has elapsed, the acknowledgement is possible as soon as the STO request has been removed.
4	After the acknowledgement, the STO and SSE are deactivated, and the control is given back to the drive.

Note: Logic states of the STO state indication signal, SSE state indication and SSE completed indication signals (output) are configurable.

SSE with time monitoring



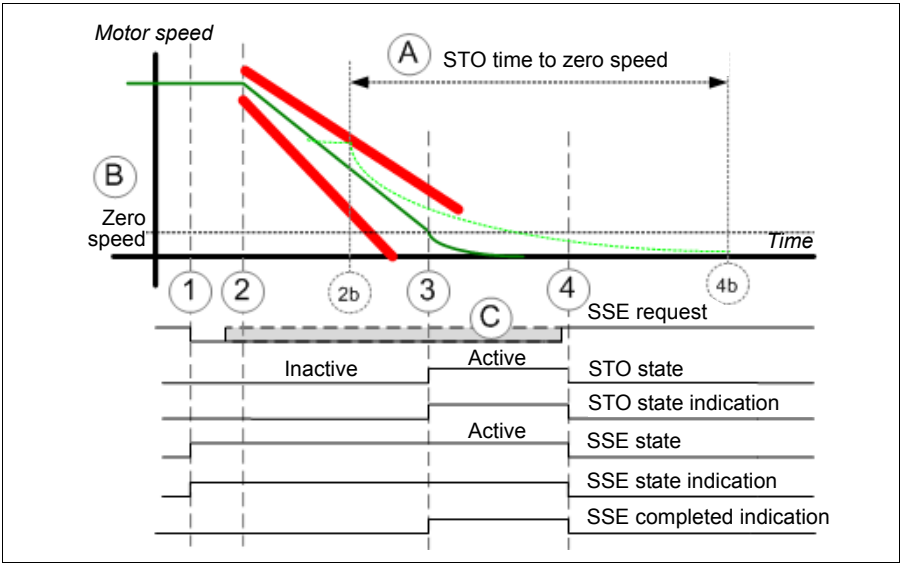
ID	Description
A	SSE delay for STO: Time after which the STO is activated regardless of the speed.
B	STO time to zero speed: Time from the STO activation to the moment when acknowledgment becomes allowed. Configured to the estimated time in which the motor coasts to a stop from the maximum speed. Relevant only if *3b* occurs.
C	Zero speed: Speed limit for activating the STO
D	SSE request removal allowed. (shaded area) The SSE request can be removed after a minimum down time. It must be removed before the acknowledgement is accepted.
E	Safety function response time
1	SSE request received (for example from the I/O)
2	Ramping down is started.
3	Speed goes below the defined zero speed limit and the STO is activated.
3b	If the drive has not ramped down fast enough when the delay for STO (A) has elapsed, the STO is activated now and the time to zero speed (B) is started.
4	After acknowledgement (manual or automatic), the STO and SSE are deactivated.
4b	If the drive had not ramped down fast enough at *3b*, acknowledgement would become allowed now.

Note: Logic states of the STO state indication signal, SSE state indication and SSE completed indication signals (output) are configurable.

Note: SSE monitoring is started immediately after the SSE request is received.

For configuration, see section *How to configure SSE with time monitoring* on page *117* in chapter *Configuration*.

SSE with ramp monitoring

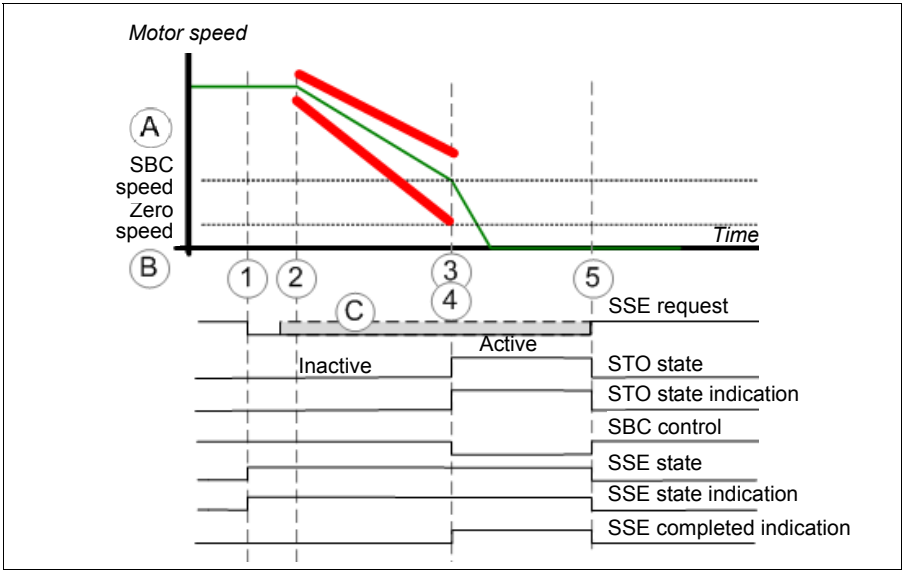


ID	Description
A	Time to zero speed. Time from the STO activation to the moment when the acknowledgment becomes allowed. Configured to the estimated time in which the motor coasts to a stop from the maximum speed. Relevant only if *2b* occurs.
B	Zero speed: Speed limit for activating the STO.
C	SSE request removal allowed (shaded area). The SSE request can be removed after a minimum down time. It must be removed before the acknowledgement is accepted.
1	SSE request received (for example from the I/O)
2	After the safety function response time, ramping down with SAR0 monitoring is started.
2b	If the drive has not followed the ramp, the STO is activated now and the time to zero speed (A) is started.
3	Speed goes below the defined zero limit, the SAR monitoring is stopped and the STO is activated.
4	After the acknowledgement (manual or automatic), the STO and SSE are deactivated, and the control is given back to the drive, which is allowed to modulate again.
4b	If the drive had not followed the ramp at *2b*, acknowledgement would become allowed now.

Note: Logic states of the STO state indication signal, SSE state indication and SSE completed indication signals (output) are configurable.

For configuration, see section *How to configure SSE with ramp monitoring* on page *119* in chapter *Configuration*.

SSE with speed limit activated SBC



ID.	Description
A	SBC speed: Speed below which the brake is activated while ramping
B	Zero speed: Speed limit for activating the STO
C	SSE request removal allowed (shaded area). The SSE request can be removed after a minimum down time. It must be removed before the acknowledgement is accepted.
1	SSE is requested (for example from the I/O).
2	Ramping down with SAR0 monitoring is started.
3	Speed is below the SBC speed; the SAR monitoring is stopped and the brake is activated
4	STO is activated after the brake activation.
5	After the acknowledgement (manual or automatic), the STO and the brake are deactivated, and the control is given back to the drive.

Note: Logic states of the STO state indication signal, SSE state indication and SSE completed indication signals (output) are configurable.

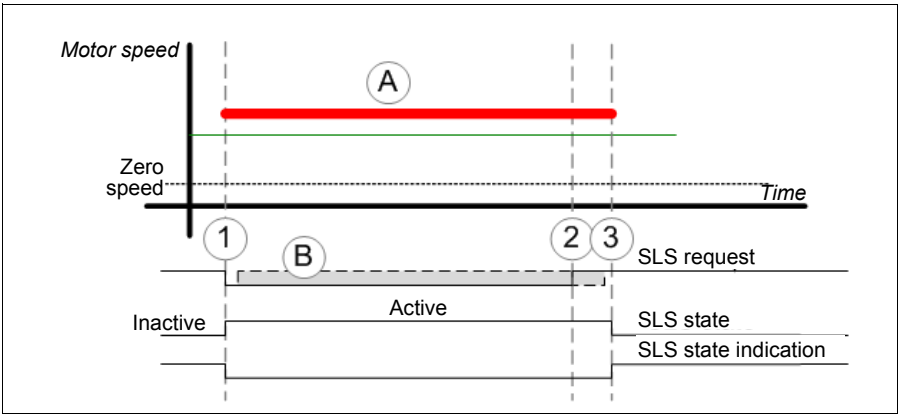
For configuration, see section *How to configure SSE with speed limit activated SBC* on page *121* in chapter *Configuration*

Safely-limited speed (SLS)

The SLS prevents the motor from exceeding the specified speed limit.

SLS with speed below monitored speed

This applies to both time and ramp monitoring.



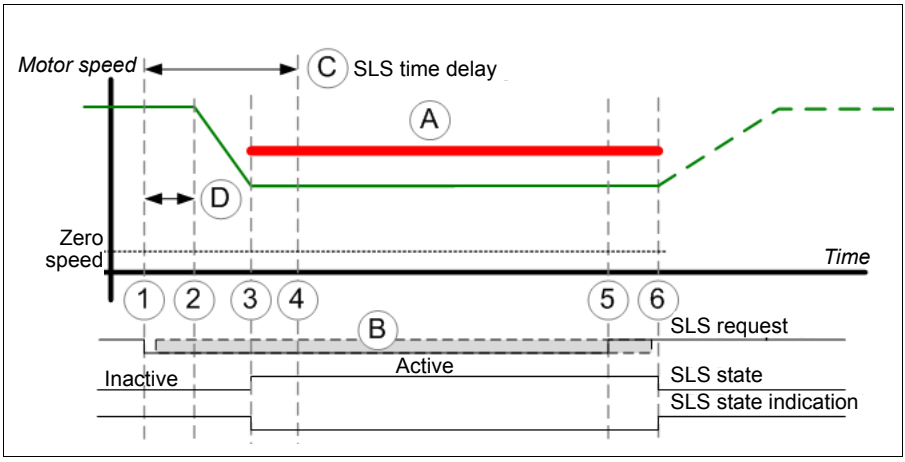
ID	Description
A	SLS upper trip limit
B	SLS request removal allowed (shaded area). The SLS request can be removed after a minimum down time. It must be removed before the acknowledgement is accepted.
1	SLS is requested, the speed is below the SLS upper trip limit and so the monitoring is started.
2	SLS request is removed, but the monitoring is still on if manual acknowledgement is configured. If automatic acknowledgement is configured, the monitoring is also ended.
3	SLS is acknowledged (manually) and the monitoring is ended.

Note: Logic state of the SLS state indication signal (output) is configurable.

For configuration, see section *Configuring SLS* on page *124* in chapter *Configuration*.

SLS with speed above monitored speed

This applies to time monitoring.



ID	Description
A	SLS upper trip limit
B	SLS request removal allowed (shaded area). The SLS request can be removed after a minimum down time. It must be removed before the acknowledgement is accepted.
C	SLS time delay: Delay for forcing to start SLS monitoring when time monitoring is in use.
D	Safety function response time
1	SLS is requested but the speed is above the SLS upper trip limit.
2	The drive starts to ramp down. If ramp monitoring were in use, the SAR1 ramp would be used from here until the speed would go below the SLS upper trip limit. If time monitoring were in use, the ramp defined by the drive parameters would be used from here until the speed would go below the SLS upper trip limit.
3	Speed is below the SLS upper trip limit and the monitoring of the SLS is started.
4	The FSO-11 would start the SLS monitoring at the latest here, that is, after the SLS time delay has elapsed.
5	SLS request is removed, but the monitoring is still on.
6	SLS is acknowledged (manually or automatically) and the monitoring is ended. When the SLS is removed, the drive continues with the previously set speed.

Note: Logic state of the SLS state indication signal (output) is configurable.

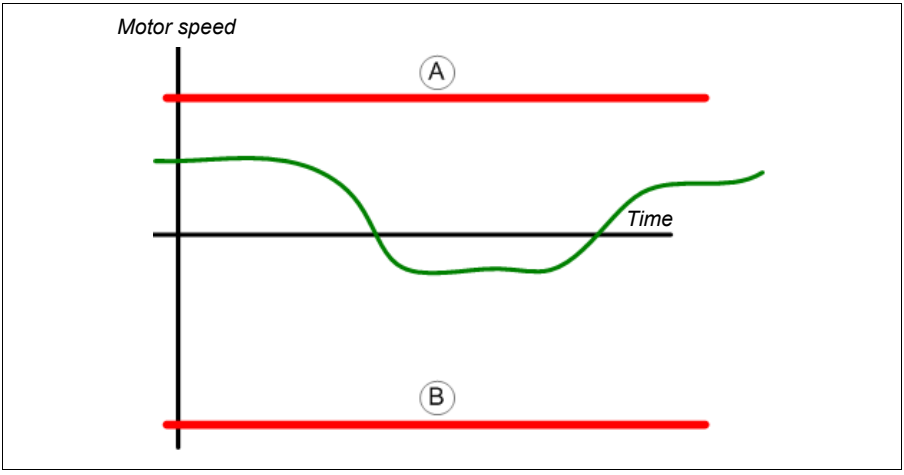
Note: If the SLS monitoring must be activated immediately, regardless of the current speed, time monitoring with zero time must be used instead of ramp monitoring.

For configuration, see section *Configuring SLS* on page *124* in chapter *Configuration*.

Safe maximum speed (SMS)

SMS is used to protect the machine from too high speeds/frequencies. It can only be configured to be on or off. The upper and lower limits can be configured separately.

If the speed should reach the maximum limit, the SSE would be activated.



ID	Description
A	SMS maximum speed
B	SMS minimum speed

For configuration, see section *Configuring SMS* on page *130* in chapter *Configuration*.

6

Planning for installation

Contents of this chapter

This chapter gives instructions and references to instructions in other manuals for planning the safety system installation, as well as the requirements for installation in the applicable safety standards.

Requirements for designers and installers

- Designers and installers must be trained to understand the requirements and principles of designing and installing safety-related systems.
- Designers and maintainers must be trained to understand the causes and consequences of Common Cause Failures (CCF). See the checklist for the appropriate standard in section *Common cause failure (CCF) checklists* on page *72*.

Mechanical installation

Installation site

The subsystem elements must always be likely to operate within the range of temperature, humidity, corrosion, dust, vibration, etc. over which it has been tested, without the use of external environmental control.

The FSO-11 module must only be used in an environment where no conductive dust or contaminants are present. One way to ensure proper protection against contamination is to use the FSO-11 in at least an IP 54 enclosure. For further information on environmental limits of the FSO-11, see chapter *Planning the mechanical installation* in the drive *Hardware manual*.

WARNING! Operating the drive system with a safety module in environmental conditions that are outside of the specified ranges for the safety module may result in losing the safety function.

Electrical installation

General requirements

Electrical installation of the safety system must be performed according to the practices outlined in chapter *Planning the electrical installation* in the drive *Hardware manual*.

Reading chapter *Installation checklists* on page *71* provides additional advice for the planning.

All wiring must be well protected, routed and clamped where practicable.

When installing cabling it must be assured that there is no pulling or pinching on the cables.

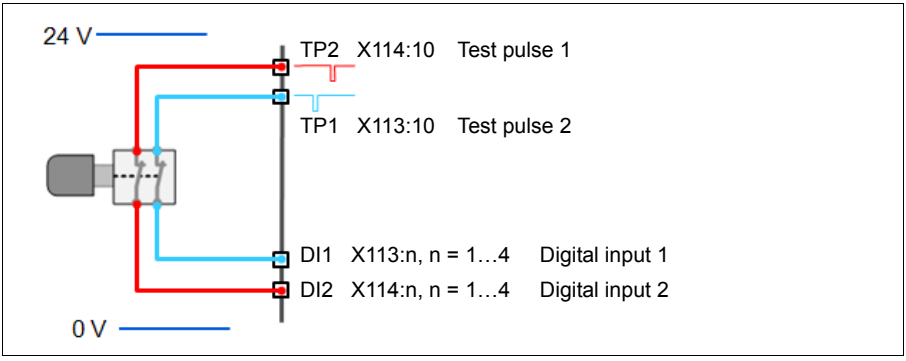
Connections

Inputs and outputs

To design the safety system architecture and select components to be used, it is essential to read and understand the different architecture options (for example single channel / redundancy).

Single inputs can be connected to any connection X113:1…4 or X114:1…4, and they can use either one of the test pulses X113:10 and X114:10.

Redundant inputs must be connected so that one input is connected to X113:n and uses test pulse X113:10, and the other is connected to X114:n and uses test pulse X114:10 (n= 1…4; the same for both inputs).



Note: Calculation software can be used to assist in selecting the appropriate architecture that will meet the safety integrity requirements for a particular application.

Power supply connection/cables

The system must be protected against over-voltage and over-current.

The length of the cabling between the FSO-11 and its power supply must be three meters or shorter, or a sufficiently low interference level must be otherwise guaranteed.

Note: The 24 V DC power supply should be equipped with a supply disconnecting device to enable the easy start-up of the FSO-11.

Ensuring the EMC compatibility

The system must only be used in the EMC environment it is designed for, or necessary mitigations must be applied.

Selecting control cables

For the control cables to on-field devices, it is recommended that shielded cabling is used. Double-shielded cable is the best alternative for low-voltage digital signals but single-shielded twisted multipair cable is also usable.

See *Control connection data* on page *151* and chapter *Planning the electrical installation* in the drive *Hardware manual*.

Routing the cables

See chapter *Planning the electrical installation* in the drive *Hardware manual*. Follow especially the rules below:

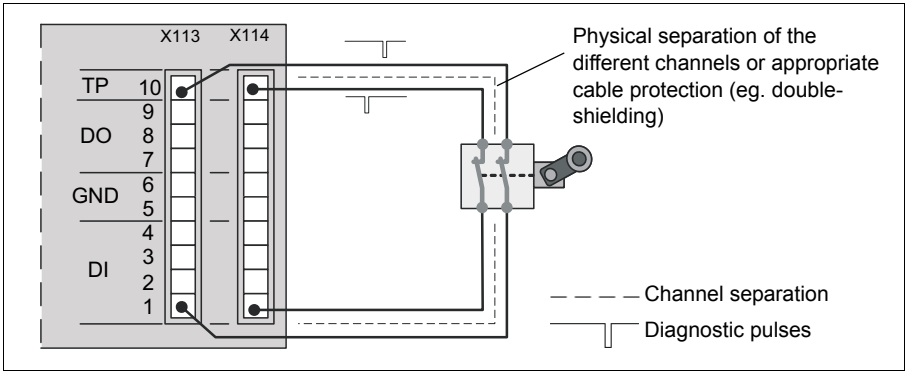
- When using redundant signaling, take care to avoid common cause failures in the cables. This can be done by routing the two channels through two well-apart routes, or by protecting the cabling appropriately, for example by using double-shielded cables.
- Never mix 24V-level signals with non-ELV-signals or power feeds in the same cable.
- Safety Related Electronic Control System (SRECS) signal cables for the individual channels must be routed separately from the other channels at all positions or sufficiently shielded.
- SRECS signal and electrical energy power cables must be separated at all positions or sufficiently shielded.
- Cross-connection between the channels of the subsystem must be prevented.
- Signal paths must be physically separated (for example separation in wiring).

Standard function and wiring examples

Passive switch

Examples:

- Limit switch
- Emergency stop button

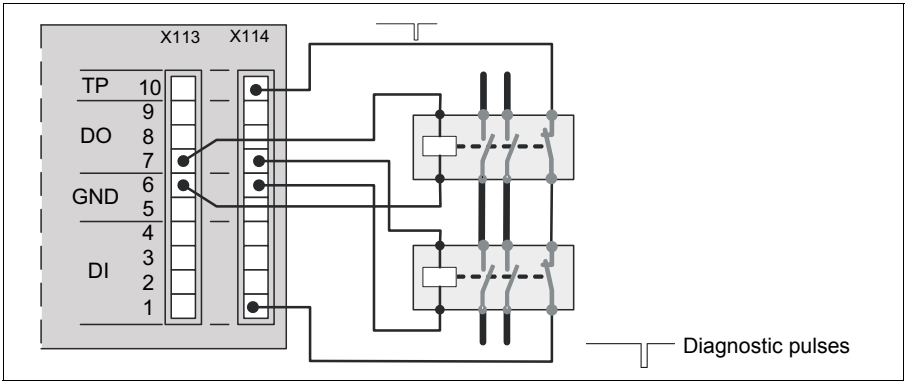


Relay / contactor output with feedback

Safety relays must have positive driven contacts. Contactors must have mechanically linked contacts.

Examples:

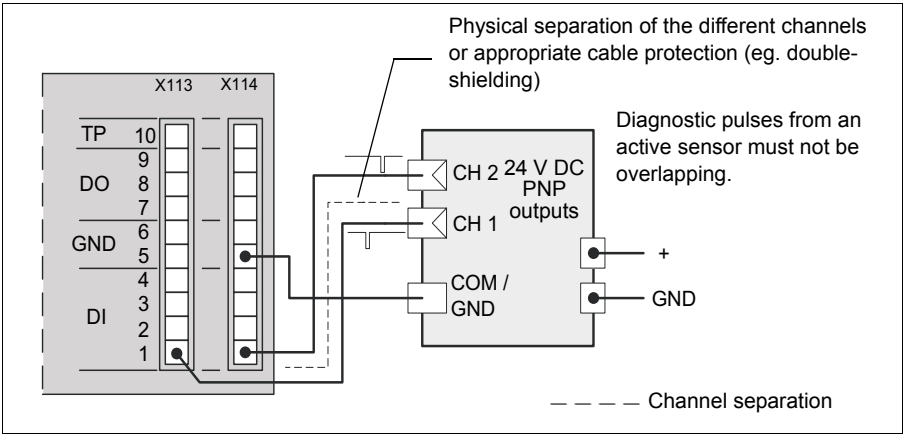
- Brake control
- Door/gate unlock



Active sensors / input signals from solid state devices

Examples:

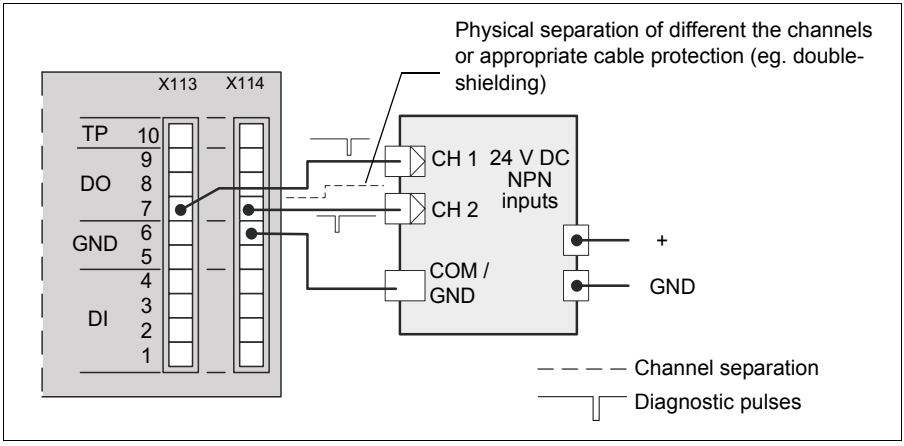
- PLC 24 V DC PNP
- Light curtain OSSD



Outputs to solid state devices

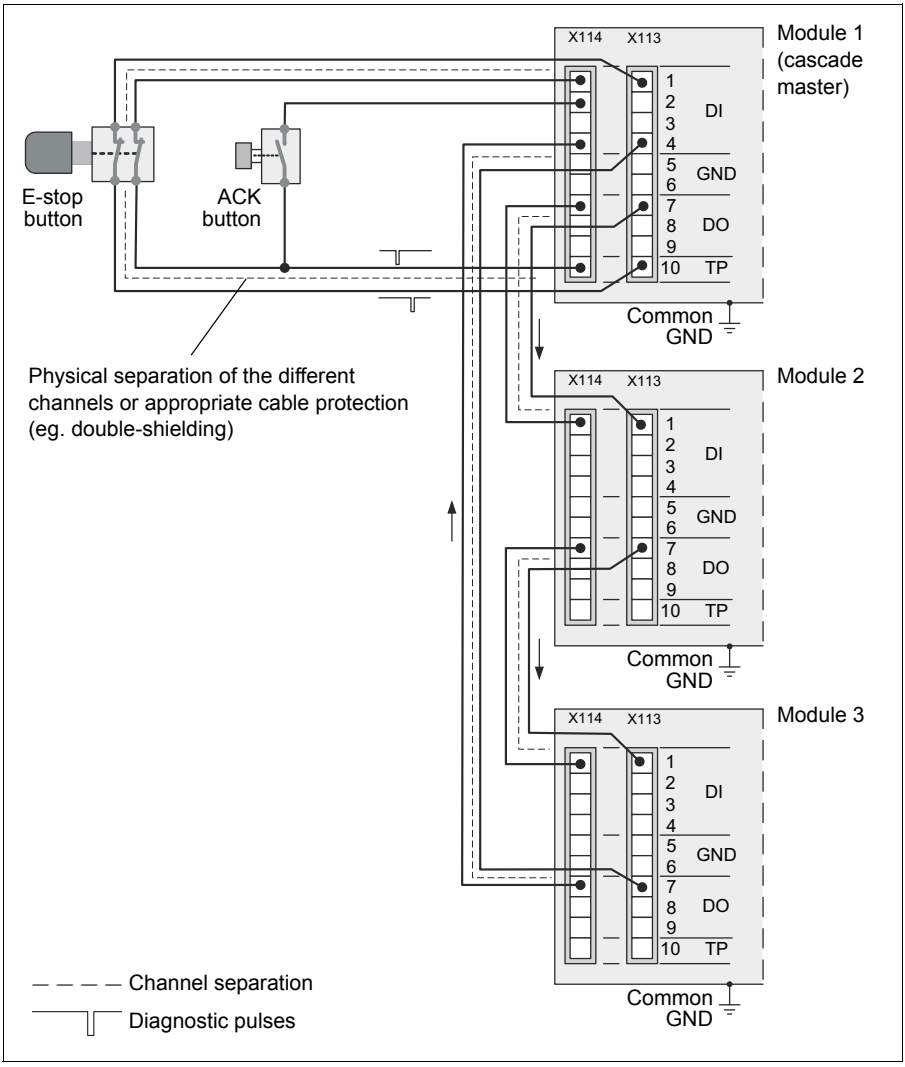
Example:

- PLC 24 V DC NPN



Cascade

Example:



7

Installation

Contents of this chapter

This chapter gives examples of how to connect the FSO-11 module to the ACS880.

WARNING! The supply voltage for FSO-11 is 24 V DC. If the FSO-11 is supplied with a higher voltage, for example 230 V or 115 V, it is damaged and needs to be replaced.

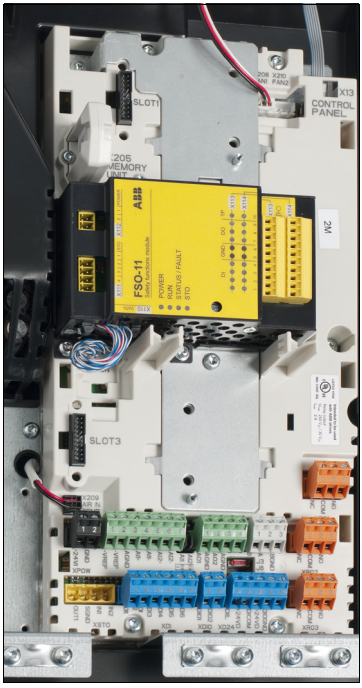
WARNING! For connecting the FSO-11 module to the drive, only use wire kits delivered by ABB.

Mechanical installation

If you have ordered the FSO-11 module option with the drive, it is delivered with the FSO-11 already installed and the FSO-11 data cable connected, so you can go directly to section *Electrical installation* on page *67*.

If you have ordered the FSO-11 module option separately, it is delivered in its own package. Install the FSO-11 mechanically on the drive as described in chapter *Mechanical installation* in the drive *Hardware manual*.

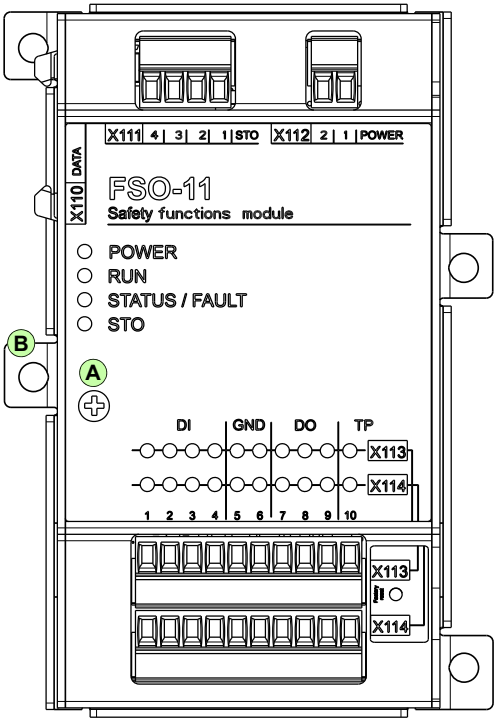
Depending on the type of the drive, the location of the module may be for example one of the following:



Electrical installation

Terminals

The connections are shown in the figure below.



A	Electronics grounding screw
B	Enclosure grounding screw, at one of the mounting points, depending on the drive type

X110:		
	DATA	Data connection to drive control unit

X111:		
1	STO	STO 24 V
2	STO	STO ground
3	STO	STO1LO drive internal signal
4	STO	STO2LO drive internal signal

X112:		
1	POWER	24 V
2	POWER	0 V

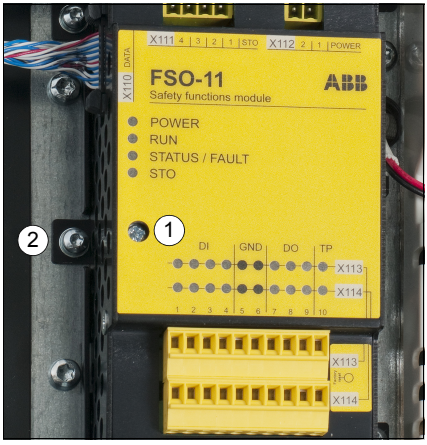
X113:		
1	DI	Channel 1 digital input 1
2	DI	Channel 1 digital input 2
3	DI	Channel 1 digital input 3
4	DI	Channel 1 digital input 4
5	GND	Signal ground
6	GND	Signal ground
7	DO	Channel 1 digital output 1
8	DO	Channel 1 digital output 2
9	DO	Channel 1 digital output 3
10	TP	Channel 1 test pulse out

X114:		
1	DI	Channel 2 digital input 1
2	DI	Channel 2 digital input 2
3	DI	Channel 2 digital input 3
4	DI	Channel 2 digital input 4
5	GND	Signal ground
6	GND	Signal ground
7	DO	Channel 2 digital output 1
8	DO	Channel 2 digital output 2
9	DO	Channel 2 digital output 3
10	TP	Channel 2 test pulse out

Connection procedure

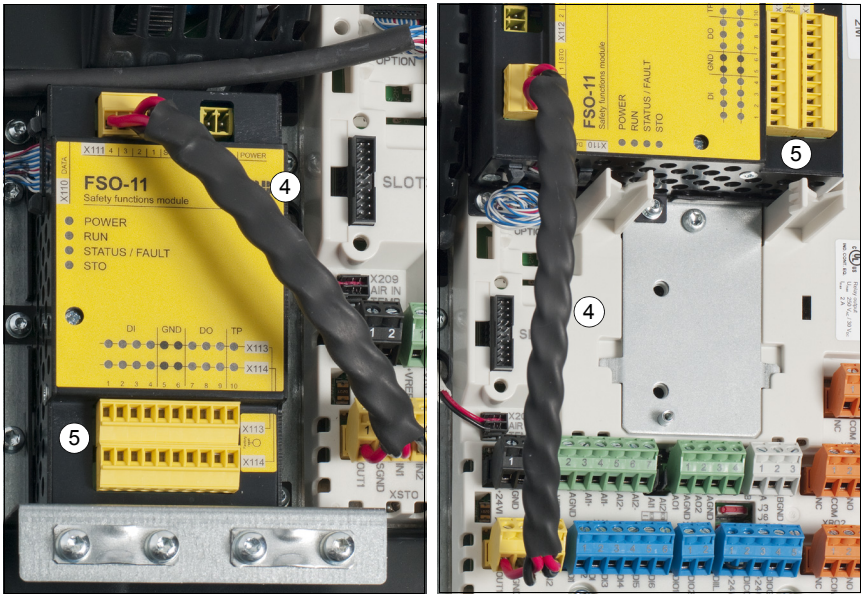
Depending on the type of the drive, the location of the module may be for example one of the following shown in the figures below.

1. Ensure that the FSO-11 electronics grounding screw is properly tightened.
2. Ensure that the FSO-11 enclosure grounding screw is properly tightened.

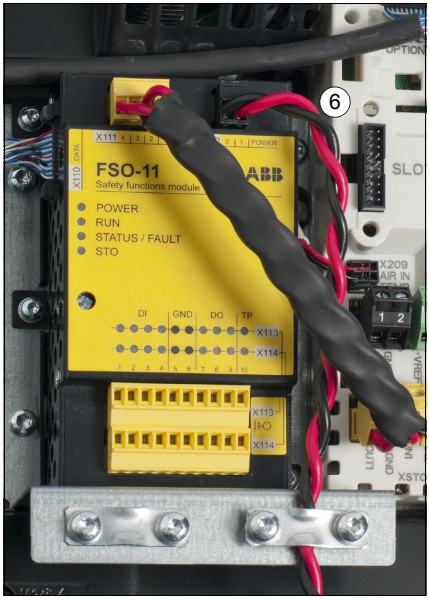


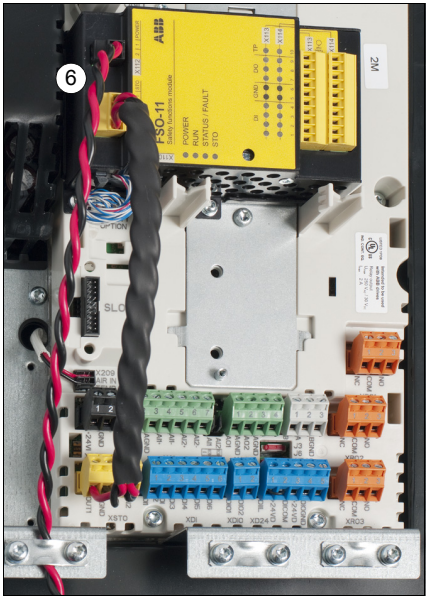
3. Ensure that the FSO-11 data cable (terminal X110) is connected to the drive.

4. Connect the supplied four-wire cable to the FSO-11 terminal X111 and plug the other end of the cable to the drive STO connection. Use the tightening torque of 0.24 Nm (2.1 lbf·in) for the FSO-11 terminals.
5. Connect the digital inputs, digital outputs, test pulses and ground at the FSO-11 terminals X113 and X114 according to the application. Use the tightening torque of 0.24 Nm (2.1 lbf·in).



6. Connect the FSO-11 power terminals X112. Use the tightening torque of 0.24 Nm (2.1 lbf·in) for the FSO-11 terminals.





8

Installation checklists

Contents of this chapter

This chapter contains a checklist for checking the mechanical and electrical installation of the FSO-11 module and refers to common cause failure checklists in standards.

Checklists

Check the mechanical and electrical installation of the FSO-11 before start-up. Go through the checklists below together with another person. Read chapter *Safety* on page *11* before you work on the safety system.

General checklist

Check
MECHANICAL INSTALLATION (See *Planning for installation* and *Installation*: *Mechanical installation*)
☐ The ambient operating conditions are within the allowed range.
☐ The module is fastened properly.
ELECTRICAL INSTALLATION (See *Planning for installation* and *Installation*: *Electrical installation*)
☐ The drive and the module are properly grounded to the same potential.
☐ If a PELV power supply is used, its ground has to be in the same potential as the drive ground.
☐ Appropriate supply (input power) fuses are installed.
☐ Signal wiring between the drive and the module is routed separately from the power supply wiring and high power cables (drive supply and motor cabling).
☐ Signal wiring is appropriately clamped, marked and protected.

Common cause failure (CCF) checklists

Check measures against common cause failures (CCF). There is one checklist in EN ISO 13849-1 and another in EN 62061. The checklists are useful for both the planning of the installation and the actual installation.

9

Configuration

Contents of this chapter

This chapter describes the password usage, outlines the configuration process, lists the FSO-11 parameters and gives examples of how to configure the FSO-11 to implement each safety function as described in chapter *Implemented safety functions* on page *33*.

Password

Note: You need a password to be able to copy the configuration to the FSO-11.

The configuration is protected with a password. You need a password to be able to upload the parameters from the drive to the FSO-11 and download the modified parameters from your PC to the FSO-11.

The password is set to “12345678” at the factory. The password must contain 4…8 digits. When you change it, do not forget the new password; otherwise you have to do a factory reset to the FSO-11 which clears the configuration and resets the parameters to the factory defaults. The password is reset to the default “12345678”. Factory defaults are not a valid configuration, so you have to reconfigure the FSO-11 or download the configuration to the FSO-11.

Configuring the FSO-11

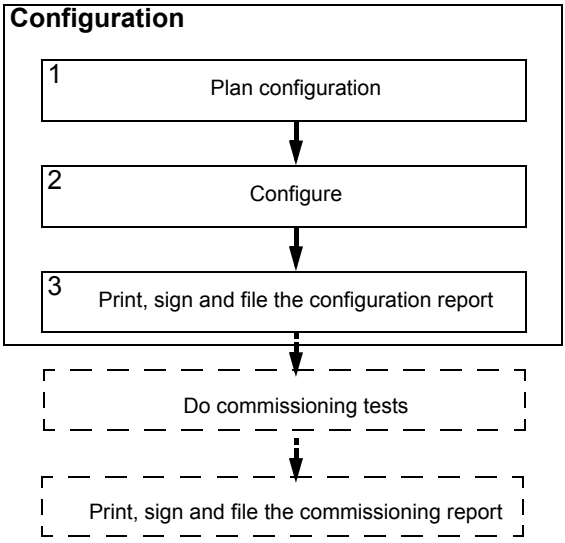
The FSO-11 parameters are set with the Drive composer pro PC tool. The names of the FSO-11 parameters and parameter settings are shown in the manual as they appear on the screen when using the tool. See the *Drive composer PC tool user's manual* (3AUA0000094606 [English]) for instructions on using the tool.

Note: Only trained persons are allowed to configure safety functions.

Note: Configuration is only possible when the motor is stopped and the drive is not modulating.

Note: After you initially start-up the FSO-11 and also after you later modify any application parameters or the configuration, you must check the safety of the entire system by doing a verification according to the system safety verification plan and by doing a validation of the correct operation of the safety application. See *Verification and validation* on page *133*.

When configuring the FSO-11, follow the steps shown in the diagram below:



1. Plan the configuration (parameter values) according to the safety system, installation, wiring, etc.
2. Set the parameter values in the Drive composer pro PC tool.
   a. Start the drive and stop the motor.
   b. Connect your PC to the drive, start the tool and select **Safety settings**.
   c. Open the parameters for setting in one of these two ways:
      - First start: Upload the parameters from the FSO-11 to the tool (button **Upload from FSO**). Password is required.
      - Existing configuration: Open the configuration file (button **Open safety file**).

d. Set the safety function parameters.
   - General parameters: Start from the general parameters. Check at least that the motor parameters are correct.
   - I/O: Check that the I/O parameters are set according to the installation (wiring) plan. Remove diagnostic pulsing from any unused I/O. Check possible safety relays and cascade connections

     Note: If there are only passive devices (for example switches) connected, do not make any changes to the diagnostic pulsing. However, if there is an active device (for example a PLC or light curtain), check if it can use the same diagnostic pulsing as the FSO-11; if not, tune the FSO-11 diagnostic pulsing.
   - Safety functions: You must at least configure the STO, regardless of what you use the FSO-11 for or which safety functions you are using. The STO is essential for the FSO-11 to be able to make the system safe; all other functions are just for monitoring the drive

e. After configuring all functions, do these two steps:
   - Save the configuration to your PC (button **Save safety file**).
   - Download the configuration to the FSO-11 **(**button **Download to FSO and validate**). Password is required.

f. After downloading, the FSO-11 and the tool validate the configuration, and the tool asks you to confirm the validation.

g. The tool then automatically reboots the drive to take the changes in use.

h. If necessary, change the password to protect the settings **(**button **Change password**). Password is required.
   Note: The motor must be stopped if you change the password.

3. After validation, print the report from the configuration, including all the values of the parameters and CRC. Sign and file the report according to your safety management plan.

Note: If you want to clear the configuration and start configuration again from the factory setup, do a factory reset. See section *Drive firmware update* on page *149*.

FSO-11 parameters

The following table lists the FSO-11 parameters: The parameter row shows parameter number, name, description and default value. The subsequent rows show the parameter value range or names, descriptions and numerical values of the selectable named alternatives.

For additional information on parameters and their settings, see the drive *Firmware manual*.

Note: When the encoderless mode is used, the unit of the speed parameters is rpm.

Note: When the FSO-11 is connected to the drive, you must set drive parameter 31.22 STO indication run/stop to value 3, 4 or 5. This setting prevents the drive from making a fault every time the FSO-11 opens the STO. The FSO-11 will generate the necessary faults to the drive event system.

Note: If Time is selected for the method of SLS activation monitoring, the ramp used is defined by the drive ramp parameters.

No	Name/Value	Description	Default / sel. value
200	**Safety**	Safety related parameters	
6	Stop completed output	Digital output indicating completion of any stop. Active if STO, SSE or SS1 is completed.	*None*
	None	No input connected	0
	DO X113:7 & X114:7	Redundant output X113:7 & X114:7	1
	DO X113:8 & X114:8	Redundant output X113:8 & X114:8	2
	DO X113:9 & X114:9	Redundant output X113:9 & X114:9	3
	DO X113:7	Single output X113:7	4
	DO X113:8	Single output X113:8	5
	DO X113:9	Single output X113:9	6
	DO X114:7	Single output X114:7	7
	DO X114:8	Single output X114:8	8
	DO X114:9	Single output X114:9	9
7	STO input A	Digital input connected to the STO primary input	*DI X113:1 & X114:1*
	None	No input connected	0
	DI X113:1 & X114:1	Redundant input X113:1 & X114:1	1
	DI X113:2 & X114:2	Redundant input X113:2 & X114:2	2
	DI X113:3 & X114:3	Redundant input X113:3 & X114:3	3
	DI X113:4 & X114:4	Redundant input X113:4 & X114:4	4
	DI X113:1	Single input X113:1	5
	DI X113:2	Single input X113:2	6
	DI X113:3	Single input X113:3	7
	DI X113:4	Single input X113:4	8

No	Name/Value	Description	Default / sel. value
	DI X114:1	Single input X114:1	9
	DI X114:2	Single input X114:2	10
	DI X114:3	Single input X114:3	11
	DI X114:4	Single input X114:4	12
8	STO input B	Digital input connected to the STO secondary input. Secondary input is mostly used for the cascade connection. See parameters *188 Cascade A* and *189 Cascade B*.	*None*
	None	No input connected	0
	DI X113:1 & X114:1	Redundant input X113:1 & X114:1	1
	DI X113:2 & X114:2	Redundant input X113:2 & X114:2	2
	DI X113:3 & X114:3	Redundant input X113:3 & X114:3	3
	DI X113:4 & X114:4	Redundant input X113:4 & X114:4	4
	DI X113:1	Single input X113:1	5
	DI X113:2	Single input X113:2	6
	DI X113:3	Single input X113:3	7
	DI X113:4	Single input X113:4	8
	DI X114:1	Single input X114:1	9
	DI X114:2	Single input X114:2	10
	DI X114:3	Single input X114:3	11
	DI X114:4	Single input X114:4	12
9	Restart delay after STO	Time after which the restart is allowed after the STO	2000 ms
	0…3,600,000 ms	Time	
11	STO SBC usage	Brake usage is always coupled with the STO. This parameter defines how.	*None*
	None	No brake	0
	Delayed brake	Time controlled brake	1
12	STO SBC delay	Brake usage delay relative to the STO. Negative value means that the brake is activated before STO activation. **Note:** Mechanical brake delays must be included in here.	3,600,000 ms
	-1000… 3,600,000 ms	Time	
15	SSE/SS1 SBC speed	Absolute speed below which the brake is activated while ramping. If the value is 0.0 rpm, this feature is not in use.	0.0 rpm
	0.0…1000.0 rpm	Speed	
16	SBC output	Digital output connected to the SBC output (brake relays)	*None*
	None	No output connected	0
	DO X113:7 & X114:7	Redundant output X113:7 & X114:7	1

No	Name/Value	Description	Default / sel. value
	DO X113:8 & X114:8	Redundant output X113:8 & X114:8	2
	DO X113:9 & X114:9	Redundant output X113:9 & X114:9	3
17	SBC feedback type	Where the SBC gets the feedback from	*Safety relay feedback*
	Safety relay feedback	Feedback is connected to a safety relay (inverted state compared with the outputs)	0
	Mechanical brake feedback	Feedback is connected to a mechanical brake (same state as the outputs, but delayed)	1
18	SBC feedback action	Action taken when there is a problem on the SBC feedback	*STO*
	STO	STO activated	0
19	STO acknowledgement	STO acknowledgement method	*Manual*
	Manual	Manual acknowledgement after the removal of requests	0
	Automatic	Automatic acknowledgement after the removal of requests	1
20	STO output	Digital output indicating activity of the STO	*None*
	None	No output connected	0
	DO X113:7 & X114:7	Redundant output X113:7 & X114:7	1
	DO X113:8 & X114:8	Redundant output X113:8 & X114:8	2
	DO X113:9 & X114:9	Redundant output X113:9 & X114:9	3
	DO X113:7	Single output X113:7	4
	DO X113:8	Single output X113:8	5
	DO X113:9	Single output X113:9	6
	DO X114:7	Single output X114:7	7
	DO X114:8	Single output X114:8	8
	DO X114:9	Single output X114:9	9
21	STO completed output	Digital output indicating completion of the STO. Active when the time defined by parameter *9 Restart delay after STO* has elapsed after the STO request.	*None*
	None	No output connected	0
	DO X113:7 & X114:7	Redundant output X113:7 & X114:7	1
	DO X113:8 & X114:8	Redundant output X113:8 & X114:8	2
	DO X113:9 & X114:9	Redundant output X113:9 & X114:9	3
	DO X113:7	Single output X113:7	4
	DO X113:8	Single output X113:8	5
	DO X113:9	Single output X113:9	6
	DO X114:7	Single output X114:7	7
	DO X114:8	Single output X114:8	8
	DO X114:9	Single output X114:9	9

No	Name/Value	Description	Default / sel. value
24	SSE time to zero speed with STO	Time in which the acknowledgement is allowed after the SSE, when the SSE activates the STO (parameter *27 SSE function* = *Immediate STO*)	3,600,000 ms
	0…3,600,000 ms	Time	
25	SSE input A	Digital input connected to the SSE primary input	*None*
	None	No input connected	0
	DI X113:1 & X114:1	Redundant input X113:1 & X114:1	1
	DI X113:2 & X114:2	Redundant input X113:2 & X114:2	2
	DI X113:3 & X114:3	Redundant input X113:3 & X114:3	3
	DI X113:4 & X114:4	Redundant input X113:4 & X114:4	4
	DI X113:1	Single input X113:1	5
	DI X113:2	Single input X113:2	6
	DI X113:3	Single input X113:3	7
	DI X113:4	Single input X113:4	8
	DI X114:1	Single input X114:1	9
	DI X114:2	Single input X114:2	10
	DI X114:3	Single input X114:3	11
	DI X114:4	Single input X114:4	12
26	SSE input B	Digital input connected to the SSE secondary input. Secondary input is mostly used for the cascade connection. See parameters *188 Cascade A* and *189 Cascade B*.	*None*
	None	No input connected	0
	DI X113:1 & X114:1	Redundant input X113:1 & X114:1	1
	DI X113:2 & X114:2	Redundant input X113:2 & X114:2	2
	DI X113:3 & X114:3	Redundant input X113:3 & X114:3	3
	DI X113:4 & X114:4	Redundant input X113:4 & X114:4	4
	DI X113:1	Single input X113:1	5
	DI X113:2	Single input X113:2	6
	DI X113:3	Single input X113:3	7
	DI X113:4	Single input X113:4	8
	DI X114:1	Single input X114:1	9
	DI X114:2	Single input X114:2	10
	DI X114:3	Single input X114:3	11
	DI X114:4	Single input X114:4	12
27	SSE function	Function activated by the SSE	*Immediate STO*
	Immediate STO	SSE activates the STO immediately	0
	Emergency ramp	SSE activates the SS1 with emergency ramp	1
28	SSE monitoring method	Method used for the SSE monitoring	*Ramp*

No	Name/Value	Description	Default / sel. value
	Ramp	Ramp monitoring	0
	Time	Time monitoring	1
29	SSE delay for STO	Time delay after which the STO is executed if time monitoring used. See parameter *28 SSE monitoring method*.	1000 ms
	0…1,800,000 ms	Time	
30	SSE output	Digital output indicating activity of the SSE	*None*
	None	No output connected	0
	DO X113:7 & X114:7	Redundant output X113:7 & X114:7	1
	DO X113:8 & X114:8	Redundant output X113:8 & X114:8	2
	DO X113:9 & X114:9	Redundant output X113:9 & X114:9	3
	DO X113:7	Single output X113:7	4
	DO X113:8	Single output X113:8	5
	DO X113:9	Single output X113:9	6
	DO X114:7	Single output X114:7	7
	DO X114:8	Single output X114:8	8
	DO X114:9	Single output X114:9	9
31	SSE completed output	Digital output indicating completion of the SSE. Active when the speed is below the speed defined by parameter *163 Zero speed without encoder* and the STO is active.	*None*
	None	No output connected	0
	DO X113:7 & X114:7	Redundant output X113:7 & X114:7	1
	DO X113:8 & X114:8	Redundant output X113:8 & X114:8	2
	DO X113:9 & X114:9	Redundant output X113:9 & X114:9	3
	DO X113:7	Single output X113:7	4
	DO X113:8	Single output X113:8	5
	DO X113:9	Single output X113:9	6
	DO X114:7	Single output X114:7	7
	DO X114:8	Single output X114:8	8
	DO X114:9	Single output X114:9	9
35	SS1 input A	Digital input connected to the SS1 primary input	*None*
	None	No input connected	0
	DI X113:1 & X114:1	Redundant input X113:1 & X114:1	1
	DI X113:2 & X114:2	Redundant input X113:2 & X114:2	2
	DI X113:3 & X114:3	Redundant input X113:3 & X114:3	3
	DI X113:4 & X114:4	Redundant input X113:4 & X114:4	4
	DI X113:1	Single input X113:1	5
	DI X113:2	Single input X113:2	6
	DI X113:3	Single input X113:3	7
	DI X113:4	Single input X113:4	8

No	Name/Value	Description	Default / sel. value
	DI X114:1	Single input X114:1	9
	DI X114:2	Single input X114:2	10
	DI X114:3	Single input X114:3	11
	DI X114:4	Single input X114:4	12
36	SS1 input B	Digital input connected to the SS1 secondary input. Secondary input is mostly used for the cascade connection. See parameters *188 Cascade A* and *189 Cascade B*.	*None*
	None	No input connected	0
	DI X113:1 & X114:1	Redundant input X113:1 & X114:1	1
	DI X113:2 & X114:2	Redundant input X113:2 & X114:2	2
	DI X113:3 & X114:3	Redundant input X113:3 & X114:3	3
	DI X113:4 & X114:4	Redundant input X113:4 & X114:4	4
	DI X113:1	Single input X113:1	5
	DI X113:2	Single input X113:2	6
	DI X113:3	Single input X113:3	7
	DI X113:4	Single input X113:4	8
	DI X114:1	Single input X114:1	9
	DI X114:2	Single input X114:2	10
	DI X114:3	Single input X114:3	11
	DI X114:4	Single input X114:4	12
37	SS1 monitoring method	Method used for the SS1 monitoring	*Ramp*
	Ramp	Ramp monitoring	0
	Time	Time monitoring	1
38	SS1 delay for STO	Time delay after which the STO is executed if time monitoring used. See parameter *37 SS1 monitoring method*.	1000 ms
	0…1,800,000 ms	Time	
39	SS1 output	Digital output indicating activity of the SS1	*None*
	None	No output connected	0
	DO X113:7 & X114:7	Redundant output X113:7 & X114:7	1
	DO X113:8 & X114:8	Redundant output X113:8 & X114:8	2
	DO X113:9 & X114:9	Redundant output X113:9 & X114:9	3
	DO X113:7	Single output X113:7	4
	DO X113:8	Single output X113:8	5
	DO X113:9	Single output X113:9	6
	DO X114:7	Single output X114:7	7
	DO X114:8	Single output X114:8	8
	DO X114:9	Single output X114:9	9

No	Name/Value	Description	Default / sel. value
40	SS1 completed output	Digital output indicating completion of the SS1. Active when the speed is below the speed defined by parameter *163 Zero speed without encoder* and the STO is active.	*None*
	None	No output connected	0
	DO X113:7 & X114:7	Redundant output X113:7 & X114:7	1
	DO X113:8 & X114:8	Redundant output X113:8 & X114:8	2
	DO X113:9 & X114:9	Redundant output X113:9 & X114:9	3
	DO X113:7	Single output X113:7	4
	DO X113:8	Single output X113:8	5
	DO X113:9	Single output X113:9	6
	DO X114:7	Single output X114:7	7
	DO X114:8	Single output X114:8	8
	DO X114:9	Single output X114:9	9
60	SLS1 input A	Digital input connected to the SLS with limits 1 (primary input)	*None*
	None	No input connected	0
	DI X113:1 & X114:1	Redundant input X113:1 & X114:1	1
	DI X113:2 & X114:2	Redundant input X113:2 & X114:2	2
	DI X113:3 & X114:3	Redundant input X113:3 & X114:3	3
	DI X113:4 & X114:4	Redundant input X113:4 & X114:4	4
	DI X113:1	Single input X113:1	5
	DI X113:2	Single input X113:2	6
	DI X113:3	Single input X113:3	7
	DI X113:4	Single input X113:4	8
	DI X114:1	Single input X114:1	9
	DI X114:2	Single input X114:2	10
	DI X114:3	Single input X114:3	11
	DI X114:4	Single input X114:4	12
61	SLS1 input B	Digital input connected to the SLS with limits 1 (secondary input). Secondary input is mostly used for cascade connection (only SLS1 can be cascaded). See parameters *188 Cascade A* and *189 Cascade B*.	*None*
	None	No input connected	0
	DI X113:1 & X114:1	Redundant input X113:1 & X114:1	1
	DI X113:2 & X114:2	Redundant input X113:2 & X114:2	2
	DI X113:3 & X114:3	Redundant input X113:3 & X114:3	3
	DI X113:4 & X114:4	Redundant input X113:4 & X114:4	4
	DI X113:1	Single input X113:1	5
	DI X113:2	Single input X113:2	6
	DI X113:3	Single input X113:3	7

No	Name/Value	Description	Default / sel. value
	DI X113:4	Single input X113:4	8
	DI X114:1	Single input X114:1	9
	DI X114:2	Single input X114:2	10
	DI X114:3	Single input X114:3	11
	DI X114:4	Single input X114:4	12
62	SLS2 input	Digital input connected to the SLS with limits 2	*None*
	None	No input connected	0
	DI X113:1 & X114:1	Redundant input X113:1 & X114:1	1
	DI X113:2 & X114:2	Redundant input X113:2 & X114:2	2
	DI X113:3 & X114:3	Redundant input X113:3 & X114:3	3
	DI X113:4 & X114:4	Redundant input X113:4 & X114:4	4
	DI X113:1	Single input X113:1	5
	DI X113:2	Single input X113:2	6
	DI X113:3	Single input X113:3	7
	DI X113:4	Single input X113:4	8
	DI X114:1	Single input X114:1	9
	DI X114:2	Single input X114:2	10
	DI X114:3	Single input X114:3	11
	DI X114:4	Single input X114:4	12
63	SLS3 input	Digital input connected to the SLS with limits 3	*None*
	None	No input connected	0
	DI X113:1 & X114:1	Redundant input X113:1 & X114:1	1
	DI X113:2 & X114:2	Redundant input X113:2 & X114:2	2
	DI X113:3 & X114:3	Redundant input X113:3 & X114:3	3
	DI X113:4 & X114:4	Redundant input X113:4 & X114:4	4
	DI X113:1	Single input X113:1	5
	DI X113:2	Single input X113:2	6
	DI X113:3	Single input X113:3	7
	DI X113:4	Single input X113:4	8
	DI X114:1	Single input X114:1	9
	DI X114:2	Single input X114:2	10
	DI X114:3	Single input X114:3	11
	DI X114:4	Single input X114:4	12
64	SLS4 input	Digital input connected to the SLS with limits 4	*None*
	None	No input connected	0
	DI X113:1 & X114:1	Redundant input X113:1 & X114:1	1
	DI X113:2 & X114:2	Redundant input X113:2 & X114:2	2
	DI X113:3 & X114:3	Redundant input X113:3 & X114:3	3
	DI X113:4 & X114:4	Redundant input X113:4 & X114:4	4
	DI X113:1	Single input X113:1	5

No	Name/Value	Description	Default / sel. value
	DI X113:2	Single input X113:2	6
	DI X113:3	Single input X113:3	7
	DI X113:4	Single input X113:4	8
	DI X114:1	Single input X114:1	9
	DI X114:2	Single input X114:2	10
	DI X114:3	Single input X114:3	11
	DI X114:4	Single input X114:4	12
65	SLS1 trip limit negative	SLS1 negative speed limit tripping the drive	-250.0 rpm
	-30000.0 …0.0 rpm	Speed	
66	SLS1 trip limit positive	SLS1 positive speed limit tripping the drive	250.0 rpm
	0.0…30000.0 rpm	Speed	
67	SLS1 limit negative	SLS1 negative speed limit for the drive	-200.0 rpm
	-30000.0 …0.0 rpm	Speed	
68	SLS1 limit positive	SLS1 positive speed limit for the drive	200.0 rpm
	0.0…30000.0 rpm	Speed	
69	SLS2 trip limit negative	SLS2 negative speed limit tripping the drive	-450.0 rpm
	-30000.0 …0.0 rpm	Speed	
70	SLS2 trip limit positive	SLS2 positive speed limit tripping the drive	450.0 rpm
	0.0…30000.0 rpm	Speed	
71	SLS2 limit negative	SLS2 negative speed limit for the drive	-400.0 rpm
	-30000.0 …0.0 rpm	Speed	
72	SLS2 limit positive	SLS2 positive speed limit for the drive	400.0 rpm
	0.0…30000.0 rpm	Speed	
73	SLS3 trip limit negative	SLS3 negative speed limit tripping the drive	-650.0 rpm
	-30000.0 …0.0 rpm	Speed	
74	SLS3 trip limit positive	SLS3 positive speed limit tripping the drive	650.0 rpm
	0.0…30000.0 rpm	Speed	
75	SLS3 limit negative	SLS3 negative speed limit for the drive	-600.0 rpm
	-30000.0 …0.0 rpm	Speed	
76	SLS3 limit positive	SLS3 positive speed limit for the drive	600.0 rpm
	0.0…30000.0 rpm	Speed	
77	SLS4 trip limit negative	SLS4 negative speed limit tripping the drive	-1050.0 rpm
	-30000.0 …0.0 rpm	Speed	
78	SLS4 trip limit positive	SLS4 positive speed limit tripping the drive	1050.0 rpm
	0.0…30000.0 rpm	Speed	

No	Name/Value	Description	Default / sel. value
79	SLS4 limit negative	SLS4 negative speed limit for the drive	-1000.0 rpm
	-30000.0 …0.0 rpm	Speed	
80	SLS4 limit positive	SLS4 positive speed limit for the drive	1000.0 rpm
	0.0…30000.0 rpm	Speed	
81	SLS activation monitoring method	Method of SLS activation monitoring	*Ramp*
	Ramp	Ramp monitoring	0
	Time	Time monitoring	1
82	SLS time delay	Delay for starting speed monitoring when time monitoring is used. See parameter *81 SLS activation monitoring method*.	4000 ms
	0…4,000,000 ms	Time	
83	SLS1 output A	Digital output connected to the SLS1 primary output	*None*
	None	No output connected	0
	DO X113:7 & X114:7	Redundant output X113:7 & X114:7	1
	DO X113:8 & X114:8	Redundant output X113:8 & X114:8	2
	DO X113:9 & X114:9	Redundant output X113:9 & X114:9	3
	DO X113:7	Single output X113:7	4
	DO X113:8	Single output X113:8	5
	DO X113:9	Single output X113:9	6
	DO X114:7	Single output X114:7	7
	DO X114:8	Single output X114:8	8
	DO X114:9	Single output X114:9	9
84	SLS1 output B	Digital output connected to the SLS1 secondary output. Secondary output is mostly used for cascade connection. See parameters *188 Cascade A* and *189 Cascade B*.	*None*
	None	No output connected	0
	DO X113:7 & X114:7	Redundant output X113:7 & X114:7	1
	DO X113:8 & X114:8	Redundant output X113:8 & X114:8	2
	DO X113:9 & X114:9	Redundant output X113:9 & X114:9	3
	DO X113:7	Single output X113:7	4
	DO X113:8	Single output X113:8	5
	DO X113:9	Single output X113:9	6
	DO X114:7	Single output X114:7	7
	DO X114:8	Single output X114:8	8
	DO X114:9	Single output X114:9	9
85	SLS2 output	Digital output connected to the SLS2	*None*
	None	No output connected	0
	DO X113:7 & X114:7	Redundant output X113:7 & X114:7	1
	DO X113:8 & X114:8	Redundant output X113:8 & X114:8	2

No	Name/Value	Description	Default / sel. value
	DO X113:9 & X114:9	Redundant output X113:9 & X114:9	3
	DO X113:7	Single output X113:7	4
	DO X113:8	Single output X113:8	5
	DO X113:9	Single output X113:9	6
	DO X114:7	Single output X114:7	7
	DO X114:8	Single output X114:8	8
	DO X114:9	Single output X114:9	9
86	SLS3 output	Digital output connected to the SLS3	*None*
	None	No output connected	0
	DO X113:7 & X114:7	Redundant output X113:7 & X114:7	1
	DO X113:8 & X114:8	Redundant output X113:8 & X114:8	2
	DO X113:9 & X114:9	Redundant output X113:9 & X114:9	3
	DO X113:7	Single output X113:7	4
	DO X113:8	Single output X113:8	5
	DO X113:9	Single output X113:9	6
	DO X114:7	Single output X114:7	7
	DO X114:8	Single output X114:8	8
	DO X114:9	Single output X114:9	9
87	SLS4 output	Digital output connected to the SLS4	*None*
	None	No output connected	0
	DO X113:7 & X114:7	Redundant output X113:7 & X114:7	1
	DO X113:8 & X114:8	Redundant output X113:8 & X114:8	2
	DO X113:9 & X114:9	Redundant output X113:9 & X114:9	3
	DO X113:7	Single output X113:7	4
	DO X113:8	Single output X113:8	5
	DO X113:9	Single output X113:9	6
	DO X114:7	Single output X114:7	7
	DO X114:8	Single output X114:8	8
	DO X114:9	Single output X114:9	9
88	SLS acknowledgement	SLS acknowledgement method	*Automatic*
	Manual	Manual acknowledgement after the removal of requests	0
	Automatic	Automatic acknowledgement after the removal of requests	1
92	SMS function	SMS activation	*Active*
	Inactive	Deactivates the SMS	0
	Active	Activates the SMS	1
93	SMS limit negative	Negative speed limit for the SMS	-2000.0 rpm
	-30000.0 …0.0 rpm	Speed	
94	SMS limit positive	Positive speed limit for the SMS	2000.0 rpm

No	Name/Value	Description	Default / sel. value
	-0.0 …30000.0 rpm	Speed	
103	SAR0 ramp time to zero	Emergency ramp target time from the “scaling speed” to the zero speed	1000 ms
	1…1,800,000 ms	Time	
104	SAR0 min ramp time to zero	Time to be subtracted from the target time to calculate the emergency ramp minimum time (-1 = not monitored)	500 ms
	-1…10,000 ms	Time	
105	SAR0 max ramp time to zero	Time to be added to the target time to calculate the emergency ramp maximum time	500 ms
	0…10,000 ms	Time	
106	SAR1 ramp time to zero	Stopping/SLS ramp target time from the “scaling speed“ to the zero speed	2000 ms
	1…1,800,000 ms	Time	
107	SAR1 min ramp time to zero	Time to be subtracted from the target time to calculate the Stopping/SLS ramp minimum time (-1 = not monitored)	500 ms
	-1…10,000 ms	Time	
108	SAR1 max ramp time to zero	Time to be added to the target time to calculate the Stopping/SLS ramp maximum time	500 ms
	0…10,000 ms	Time	
127	SAR initial allowed range	Initial allowed range for the SAR (min/max modifies the range when the ramp goes on)	100 ms
	0…60,000 ms	Time	
161	Power-up acknowledgement	Power-up acknowledgement method	*Manual*
	Manual	Manual acknowledgement after the removal of requests	0
	Automatic	Automatic acknowledgement after the removal of requests	1
162	Acknowledgement button input	Digital input connected to the button for acknowledging operations	*None*
	None	No input connected	0
	DI X113:1	Single input X113:1	5
	DI X113:2	Single input X113:2	6
	DI X113:3	Single input X113:3	7
	DI X113:4	Single input X113:4	8
	DI X114:1	Single input X114:1	9
	DI X114:2	Single input X114:2	10
	DI X114:3	Single input X114:3	11
	DI X114:4	Single input X114:4	12
163	Zero speed without encoder	General zero speed limit for safety functions when no safety encoder in use	90.0 rpm

No	Name/Value	Description	Default / sel. value
	6.0…600.0 rpm	Speed	
165	Motor nominal speed	Defines the nominal motor speed	1500.0 rpm
	1.0 …30000.0 rpm	Speed	
166	Motor nominal frequency	Defines the nominal motor frequency	50.00 Hz
	0.00…500.00 Hz	Frequency	
167	STO indication ext request	Type of the generated event for an external request (STO, SSE or SS1) ending in the STO (faults generating the STO are always faults)	*Fault*
	None	No event generated	0
	Fault	Fault generated	1
	Warning	Warning generated	2
	Event	Pure event generated	3
168	STO indication safety limit	Type of the generated event for the STO or SSE caused by a safety function limit hit (faults generating the STO are always faults)	*Fault*
	None	No event generated	0
	Fault	Fault generated	1
	Warning	Warning generated	2
	Event	Pure event generated	3
181	M/F mode for cascade	Master/follower mode of this FSO-11 module for both cascade channels separately	*A = follower, B = follower*
	A = follower, B = follower	This module is a follower on cascade connection A and a follower on cascade connection B.	0
	A = master, B = follower	This module is the master on cascade connection A and a follower on cascade connection B.	1
	A = follower, B = master	This module is a follower on cascade connection A and the master on cascade connection B.	2
	A = master, B = master	This module is the master on cascade connection A and the master on cascade connection B.	3
182	DO X113:7 logic state	Logic state of digital output X113:7	*Active low*
	Active low	Active state of the output is low voltage.	0
	Active high	Active state of the output is high voltage.	1
183	DO X113:8 logic state	Logic state of digital output X113:8	*Active low*
	Active low	Active state of the output is low voltage.	0
	Active high	Active state of the output is high voltage.	1
184	DO X113:9 logic state	Logic state of digital output X113:9	*Active low*
	Active low	Active state of the output is low voltage.	0
	Active high	Active state of the output is high voltage.	1

No	Name/Value	Description	Default / sel. value
185	DO X114:7 logic state	Logic state of digital output X114:7	*Active low*
	Active low	Active state of the output is low voltage.	0
	Active high	Active state of the output is high voltage.	1
186	DO X114:8 logic state	Logic state of digital output X114:8	*Active low*
	Active low	Active state of the output is low voltage.	0
	Active high	Active state of the output is high voltage.	1
187	DO X114:9 logic state	Logic state of digital output X114:9	*Active low*
	Active low	Active state of the output is low voltage.	0
	Active high	Active state of the output is high voltage.	1
188	Cascade A	For each FSO module in cascade A, the digital input connected to the safety function is also internally connected to the corresponding digital output of the module (digital input -> digital output). This resembles a master/follower connection. See section *Cascade* on page *38*.	*None*
	None	Not cascaded	0
	X113:1 & X114:1 -> X113:7 & X114:7	Redundant cascade X113:1 & X114:1 -> X113:7 & X114:7	1
	X113:2 & X114:2 -> X113:8 & X114:8	Redundant cascade X113:2 & X114:2 -> X113:8 & X114:8	2
	X113:3 & X114:3 -> X113:9 & X114:9	Redundant cascade X113:3 & X114:3 -> X113:9 & X114:9	3
	X113:1 -> X113:7	Single cascade X113:1 -> X113:7	4
	X113:2 -> X113:8	Single cascade X113:2 -> X113:8	5
	X113:3 -> X113:9	Single cascade X113:3 -> X113:9	6
	X114:1 -> X114:7	Single cascade X114:1 -> X114:7	7
	X114:2 -> X114:8	Single cascade X114:2 -> X114:8	8
	X114:3 -> X114:9	Single cascade X114:3 -> X114:9	9
189	Cascade B	For each FSO module in cascade B, the digital input connected to the safety function is also internally connected to the corresponding digital output of the module (digital input -> digital output). See section *Cascade* on page *38*.	*None*
	None	Not cascaded	0
	X113:1 & X114:1 -> X113:7 & X114:7	Redundant cascade X113:1 & X114:1 -> X113:7 & X114:7	1
	X113:2 & X114:2 -> X113:8 & X114:8	Redundant cascade X113:2 & X114:2 -> X113:8 & X114:8	2
	X113:3 & X114:3 -> X113:9 & X114:9	Redundant cascade X113:3 & X114:3 -> X113:9 & X114:9	3

No	Name/Value	Description	Default / sel. value
	X113:1 -> X113:7	Single cascade X113:1 -> X113:7	4
	X113:2 -> X113:8	Single cascade X113:2 -> X113:8	5
	X113:3 -> X113:9	Single cascade X113:3 -> X113:9	6
	X114:1 -> X114:7	Single cascade X114:1 -> X114:7	7
	X114:2 -> X114:8	Single cascade X114:2 -> X114:8	8
	X114:3 -> X114:9	Single cascade X114:3 -> X114:9	9
190	DI diagnostic pulse length	Length of the diagnostic pulse for digital inputs	*0.5 ms*
	0.5 ms		0
	1 ms		1
	2 ms		2
191	DI diagnostic pulse period	Cycle time of the diagnostic pulse falling edge for digital inputs (time between diagnostic pulse falling edges)	10,000 ms
	50…59,000 ms	Time	
192	DI X113:1 diag pulse on/off	Diagnostic pulse of digital input X113:1 on or off	*On*
	Off	Diagnostic pulse off	0
	On	Diagnostic pulse on	1
193	DI X113:2 diag pulse on/off	Diagnostic pulse of digital input X113:2 on or off	*On*
	Off	Diagnostic pulse off	0
	On	Diagnostic pulse on	1
194	DI X113:3 diag pulse on/off	Diagnostic pulse of digital input X113:3 on or off	*On*
	Off	Diagnostic pulse off	0
	On	Diagnostic pulse on	1
195	DI X113:4 diag pulse on/off	Diagnostic pulse of digital input X113:4 on or off	*On*
	Off	Diagnostic pulse off	0
	On	Diagnostic pulse on	1
196	DI X114:1 diag pulse on/off	Diagnostic pulse of digital input X114:1 on or off	*On*
	Off	Diagnostic pulse off	0
	On	Diagnostic pulse on	1
197	DI X114:2 diag pulse on/off	Diagnostic pulse of digital input X114:2 on or off	*On*
	Off	Diagnostic pulse off	0
	On	Diagnostic pulse on	1
198	DI X114:3 diag pulse on/off	Diagnostic pulse of digital input X114:3 on or off	*On*
	Off	Diagnostic pulse off	0
	On	Diagnostic pulse on	1

No	Name/Value	Description	Default / sel. value
199	DI X114:4 diag pulse on/off	Diagnostic pulse of digital input X114:4 on or off	*On*
	Off	Diagnostic pulse off	0
	On	Diagnostic pulse on	1
200	DO diagnostic pulse length	Length of the diagnostic pulse for digital outputs	*1 ms*
	0.5 ms		0
	1 ms		1
	2 ms		2
201	DO diagnostic pulse period	Cycle time of the diagnostic pulse falling edge for digital outputs (time between diagnostic pulse falling edges)	10,000 ms
	30…59,000 ms	Time	
202	DO X113:7 diag pulse on/of	Diagnostic pulse of digital output X113:7 on or off	*On*
	Off	Diagnostic pulse off	0
	On	Diagnostic pulse on	1
203	DO X113:8 diag pulse on/off	Diagnostic pulse of digital output X113:8 on or off	*On*
	Off	Diagnostic pulse off	0
	On	Diagnostic pulse on	1
204	DO X113:9 diag pulse on/off	Diagnostic pulse of digital output X113:9 on or off	*On*
	Off	Diagnostic pulse off	0
	On	Diagnostic pulse on	1
205	DO X114:7 diag pulse on/off	Diagnostic pulse of digital output X114:7 on or off	*On*
	Off	Diagnostic pulse off	0
	On	Diagnostic pulse on	1
206	DO X114:8 diag pulse on/off	Diagnostic pulse of digital output X114:8 on or off	*On*
	Off	Diagnostic pulse off	0
	On	Diagnostic pulse on	1
207	DO X114:9 diag pulse on/off	Diagnostic pulse of digital output X114:9 on or off	*On*
	Off	Diagnostic pulse off	0
	On	Diagnostic pulse on	1
208	Safety relay 1 output	Output for the safety relay 1	*None*
	None	No output connected	0
	DO X113:7 & X114:7	Redundant output X113:7 & X114:7	1
	DO X113:8 & X114:8	Redundant output X113:8 & X114:8	2
	DO X113:9 & X114:9	Redundant output X113:9 & X114:9	3
209	Safety relay 1 feedback	Feedback input of the safety relay 1	*None*

No	Name/Value	Description			Default / sel. value
	None	No input connected			0
	DI X113:1	Single input X113:1			5
	DI X113:2	Single input X113:2			6
	DI X113:3	Single input X113:3			7
	DI X113:4	Single input X113:4			8
	DI X114:1	Single input X114:1			9
	DI X114:2	Single input X114:2			10
	DI X114:3	Single input X114:3			11
	DI X114:4	Single input X114:4			12
210	Safety relay 2 output	Output for the safety relay 2			*None*
	None	No output connected			0
	DO X113:7 & X114:7	Redundant output X113:7 & X114:7			1
	DO X113:8 & X114:8	Redundant output X113:8 & X114:8			2
	DO X113:9 & X114:9	Redundant output X113:9 & X114:9			3
211	Safety relay 2 feedback	Feedback input of the safety relay 2			*None*
	None	No input connected			0
	DI X113:1	Single input X113:1			5
	DI X113:2	Single input X113:2			6
	DI X113:3	Single input X113:3			7
	DI X113:4	Single input X113:4			8
	DI X114:1	Single input X114:1			9
	DI X114:2	Single input X114:2			10
	DI X114:3	Single input X114:3			11
	DI X114:4	Single input X114:4			12
241	FSO DI status	States of the FSO inputs			
		Bit	**Name**	**Values**	
		0	Input X113:1	0 = Off, 1 = On	
		1	Input X113:2	0 = Off, 1 = On	
		2	Input X113:3	0 = Off, 1 = On	
		3	Input X113:4	0 = Off, 1 = On	
		4	Input X114:1	0 = Off, 1 = On	
		5	Input X114:2	0 = Off, 1 = On	
		6	Input X114:3	0 = Off, 1 = On	
		7	Input X114:4	0 = Off, 1 = On	

No	Name/Value	Description			Default / sel. value
242	FSO DO status	States of the FSO outputs			
		Bit	**Name**	**Values**	
		0	Output X113:7	0 = Off, 1 = On	
		1	Output X113:8	0 = Off, 1 = On	
		2	Output X113:9	0 = Off, 1 = On	
		3	Output X114:7	0 = Off, 1 = On	
		4	Output X114:8	0 = Off, 1 = On	
		5	Output X114:9	0 = Off, 1 = On	
243	FSO control word 1	States of the FSO commands			
		Bit	**Name**	**Values**	
		0	STO request	0 = Off, 1 = On	
		1	SSE request	0 = Off, 1 = On	
		2	SS1 request	0 = Off, 1 = On	
		4	SAR0 request	0 = Off, 1 = On	
		5	SAR1 request	0 = Off, 1 = On	
		10	SLS1 request	0 = Off, 1 = On	
		11	SLS2 request	0 = Off, 1 = On	
		12	SLS3 request	0 = Off, 1 = On	
		13	SLS4 request	0 = Off, 1 = On	
244	FSO control word 2	States of the FSO commands			
		Bit	**Name**	**Values**	
		0	SDI negative request	0 = Off, 1 = On	
		1	CRC request	0 = Off, 1 = On	
		2	FSO brake	0 = Off, 1 = On	
245	FSO status word 1	FSO status word 1			
		Bit	**Name**	**Values**	
		0	FSO mode bit 1	0 = Undefined 1 = Boot mode 2 = Running mode 3 = Fail safe mode 4 = Configuration mode	
		1	FSO mode bit 2		
		2	FSO mode bit 3		
		3	FSO state bit	0 = Safe state 1 = Operational	
		5	FSO STO active	0 = Off, 1 = On	
		6	Brake state	0 = Off, 1 = On	
		8	SSE monitoring	0 = Off, 1 = On	
		9	SS1 monitoring	0 = Off, 1 = On	
		11	SAR0 monitoring	0 = Off, 1 = On	
		12	SAR1 monitoring	0 = Off, 1 = On	

<table>
<tr><th>No Name/Value</th><th colspan="4">Description</th><th>Default / sel. value</th></tr>
<tr><td>246 FSO status word 2</td><td colspan="4">FSO status word 2<table>
<tr><th>Bit</th><th>Name</th><th>Values</th></tr>
<tr><td>1</td><td>SLS1 monitoring</td><td>0 = Off, 1 = On</td></tr>
<tr><td>2</td><td>SLS2 monitoring</td><td>0 = Off, 1 = On</td></tr>
<tr><td>3</td><td>SLS3 monitoring</td><td>0 = Off, 1 = On</td></tr>
<tr><td>4</td><td>SLS4 monitoring</td><td>0 = Off, 1 = On</td></tr>
<tr><td>6</td><td>SDI positive monitoring</td><td>0 = Off, 1 = On</td></tr>
<tr><td>7</td><td>SDI negative monitoring</td><td>0 = Off, 1 = On</td></tr>
<tr><td>12</td><td>SMS monitoring</td><td>0 = Off, 1 = On</td></tr>
</table></td><td></td></tr>
<tr><td>247 Drive status word 1</td><td colspan="4">Drive status word 1<table>
<tr><th>Bit</th><th>Name</th><th>Description</th><th>Values</th></tr>
<tr><td>0</td><td>Drive status bit 1</td><td></td><td rowspan="4">0 = Disabled
1 = Readyon
2 = Readyrun
3 = Starting
4 = Readyref
5 = Stopping
6 = Faulted</td></tr>
<tr><td>1</td><td>Drive status bit 2</td><td></td></tr>
<tr><td>2</td><td>Drive status bit 3</td><td></td></tr>
<tr><td>3</td><td>Drive status bit 4</td><td></td></tr>
<tr><td>4</td><td>Brake proof test</td><td>Drive requests a brake proof test.</td><td>0 = Off, 1 = On</td></tr>
<tr><td>5</td><td>Encoder present</td><td></td><td>0 = Off, 1 = On</td></tr>
<tr><td>6</td><td>Modulation</td><td></td><td>0 = Off, 1 = On</td></tr>
<tr><td>7</td><td>STO circuit 1</td><td></td><td>0 = Off, 1 = On</td></tr>
<tr><td>8</td><td>STO circuit 2</td><td></td><td>0 = Off, 1 = On</td></tr>
<tr><td>9</td><td>SS1 active</td><td rowspan="3">State on the drive side</td><td>0 = Off, 1 = On</td></tr>
<tr><td>11</td><td>SAR0 active</td><td>0 = Off, 1 = On</td></tr>
<tr><td>12</td><td>SAR1 active</td><td>0 = Off, 1 = On</td></tr>
</table></td><td></td></tr>
</table>

<table>
<tr><th>No</th><th>Name/Value</th><th colspan="4">Description</th><th>Default / sel. value</th></tr>
<tr><td>248</td><td>Drive status word 2</td><td colspan="4">Drive status word 2</td><td></td></tr>
<tr><td></td><td></td><td>Bit</td><td>Name</td><td>Description</td><td>Values</td><td></td></tr>
<tr><td></td><td></td><td>1</td><td>SLS1 active</td><td rowspan="6">State on the drive side</td><td>0 = Off, 1 = On</td><td></td></tr>
<tr><td></td><td></td><td>2</td><td>SLS2 active</td><td>0 = Off, 1 = On</td><td></td></tr>
<tr><td></td><td></td><td>3</td><td>SLS3 active</td><td>0 = Off, 1 = On</td><td></td></tr>
<tr><td></td><td></td><td>4</td><td>SLS4 active</td><td>0 = Off, 1 = On</td><td></td></tr>
<tr><td></td><td></td><td>6</td><td>SDI positive active</td><td>0 = Off, 1 = On</td><td></td></tr>
<tr><td></td><td></td><td>7</td><td>SDI negative active</td><td>0 = Off, 1 = On</td><td></td></tr>
<tr><td></td><td></td><td>8</td><td>Drive brake</td><td></td><td>0 = Off, 1 = On</td><td></td></tr>
<tr><td></td><td></td><td>9</td><td>STO 1 diag</td><td rowspan="2">Drive has noticed an STO diag-nostic pulse on circuit 1/2.</td><td>0, 1</td><td></td></tr>
<tr><td></td><td></td><td>10</td><td>STO 2 diag</td><td>0, 1</td><td></td></tr>
<tr><td>252</td><td>FSO configuration version</td><td colspan="4">FSO user configuration version</td><td></td></tr>
<tr><td></td><td>0…4294967295</td><td colspan="4"></td><td></td></tr>
</table>

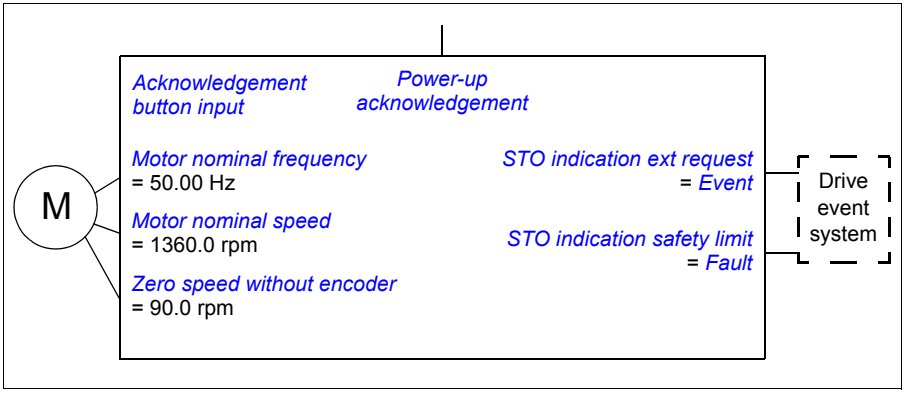
Configuring general settings

How to configure general settings

To configure the general settings, set the FSO-11 parameters listed in the table below to appropriate values using the Drive composer pro PC tool.

Example: The figure below and the Example value column in the table show an example I/O set-up:

- Acknowledgement button is connected to input X114:4. After power-up the acknowledgement can only be performed manually.
- Motor nominal frequency 50.00 Hz
- Motor nominal speed 1360.0 rpm
- Zero speed 90.0 rpm
- External requests ending in the STO are reported to the drive as events. Other safety function limit hits are reported as faults.


Acknowledgement button input
Power-up acknowledgement
Motor nominal frequency = 50.00 Hz
Motor nominal speed = 1360.0 rpm
Zero speed without encoder = 90.0 rpm
M
STO indication ext request = Event
STO indication safety limit = Fault
Drive event system

No	Name/Value	Description	Example value
200	**Safety**	Safety parameters	
161	*Power-up acknowledgement*	Power-up acknowledgement method	*Manual*
	Manual	Manual acknowledgement after the removal of requests	0
162	*Acknowledgement button input*	Digital input connected to the button for acknowledging operations	*DI X114:4*
	DI X114:4	Single input X114:4	12
163	*Zero speed without encoder*	General zero speed limit for safety functions when no safety encoder in use	90.0 rpm
165	*Motor nominal speed*	Defines the nominal motor speed	1360.0 rpm

No	Name/Value	Description	Example value
166	*Motor nominal frequency*	Defines the nominal motor frequency	50.00 Hz
167	*STO indication ext request*	Type of the generated event for an external request (STO, SSE or SS1) ending in the STO (faults generating the STO are always faults)	*Event*
	Event	Pure event generated	3
168	*STO indication safety limit*	Type of the generated event for the STO or SSE caused by a safety function limit hit (faults generating the STO are always faults)	*Fault*
	Fault	Fault generated	1

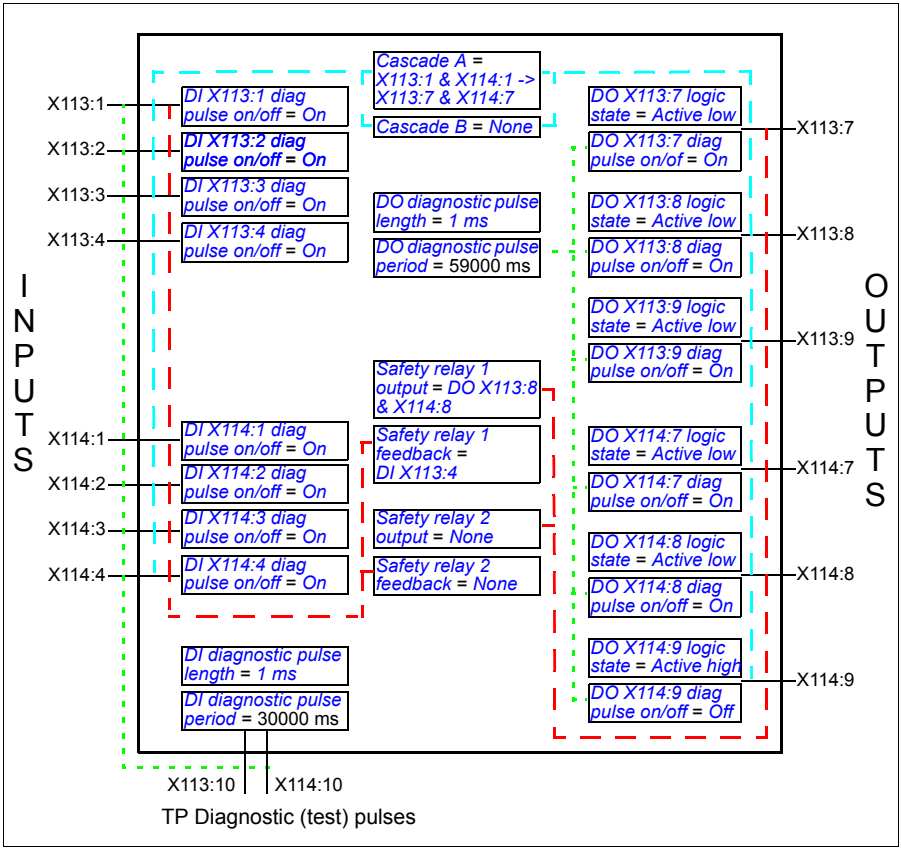
Configuring I/O

How to configure I/O

To configure the I/O, set the FSO-11 parameters listed in the table below to appropriate values using the Drive composer pro PC tool. The location of the input and output terminals on the FSO-11 module is shown in section *Layout* on page *29*.

Example: The figure below and the Example value column in the table show an example I/O set-up:

- All inputs use diagnostic pulses with 1 ms width and 30 s period.
- one redundant cascaded connection from input 1 to output 7
- one safety relay (always redundant) connected to output 8 with feedback connected to input 3
- All outputs, except X114:9, have active low logic state and diagnostic pulsing on. Pulse width 1 ms and period 59 s.
- Output X114:9 has active high logic state and no diagnostics pulses can be used.


INPUTS
OUTPUTS
X113:1
X113:2
X113:3
X113:4
X114:1
X114:2
X114:3
X114:4
DI X113:1 diag pulse on/off = On
DI X113:2 diag pulse on/off = On
DI X113:3 diag pulse on/off = On
DI X113:4 diag pulse on/off = On
DI X114:1 diag pulse on/off = On
DI X114:2 diag pulse on/off = On
DI X114:3 diag pulse on/off = On
DI X114:4 diag pulse on/off = On
DI diagnostic pulse length = 1 ms
DI diagnostic pulse period = 30000 ms
Cascade A = X113:1 & X114:1 -> X113:7 & X114:7
Cascade B = None
DO diagnostic pulse length = 1 ms
DO diagnostic pulse period = 59000 ms
Safety relay 1 output = DO X113:8 & X114:8
Safety relay 1 feedback = DI X113:4
Safety relay 2 output = None
Safety relay 2 feedback = None
DO X113:7 logic state = Active low
DO X113:7 diag pulse on/of = On
DO X113:8 logic state = Active low
DO X113:8 diag pulse on/off = On
DO X113:9 logic state = Active low
DO X113:9 diag pulse on/off = On
DO X114:7 logic state = Active low
DO X114:7 diag pulse on/off = On
DO X114:8 logic state = Active low
DO X114:8 diag pulse on/off = On
DO X114:9 logic state = Active high
DO X114:9 diag pulse on/off = Off
X113:7
X113:8
X113:9
X114:7
X114:8
X114:9
X113:10
X114:10
TP Diagnostic (test) pulses

Note: The safety relay inputs and outputs must be configured so that in the safe state the circuit is disconnected (0 V).

Inputs

Set the length and period of the diagnostic pulse for the digital inputs. Select for each input whether the diagnostic pulse is on or off.

No	Name/Value	Description	Example value
200	**Safety**	Safety parameters	
190	*DI diagnostic pulse length*	Length of the diagnostic pulse for digital inputs	*1 ms*
	1 ms		1
191	*DI diagnostic pulse period*	Cycle time of the diagnostic pulse falling edge for digital inputs (time between diagnostic pulse falling edges)	30,000 ms
192	*DI X113:1 diag pulse on/off*	Diagnostic pulse of digital input X113:1 on or off	*On*
	On	Diagnostic pulse on	1
193	*DI X113:2 diag pulse on/off*	Diagnostic pulse of digital input X113:2 on or off	*On*
	On	Diagnostic pulse on	1
194	*DI X113:3 diag pulse on/off*	Diagnostic pulse of digital input X113:3 on or off	*On*
	On	Diagnostic pulse on	1
195	*DI X113:4 diag pulse on/off*	Diagnostic pulse of digital input X113:4 on or off	*On*
	On	Diagnostic pulse on	1
196	*DI X114:1 diag pulse on/off*	Diagnostic pulse of digital input X114:1 on or off	*On*
	On	Diagnostic pulse on	1
197	*DI X114:2 diag pulse on/off*	Diagnostic pulse of digital input X114:2 on or off	*On*
	On	Diagnostic pulse on	1
198	*DI X114:3 diag pulse on/off*	Diagnostic pulse of digital input X114:3 on or off	*On*
	On	Diagnostic pulse on	1
199	*DI X114:4 diag pulse on/off*	Diagnostic pulse of digital input X114:4 on or off	*On*
	On	Diagnostic pulse off	1

Outputs

Set the logic state for each digital output. Set the length and period of the diagnostic pulse for the digital outputs. Select for each output whether the diagnostic pulse is on or off.

No	Name/Value	Description	Example value
200	**Safety**	Safety parameters	
182	*DO X113:7 logic state*	Logic state of digital output X113:7	*Active low*

No	Name/Value	Description	Example value
	Active low	Active state of the output is low voltage.	0
183	*DO X113:8 logic state*	Logic state of digital output X113:8	*Active low*
	Active low	Active state of the output is low voltage.	0
184	*DO X113:9 logic state*	Logic state of digital output X113:9	*Active low*
	Active low	Active state of the output is low voltage.	0
185	*DO X114:7 logic state*	Logic state of digital output X114:7	*Active low*
	Active low	Active state of the output is low voltage.	0
186	*DO X114:8 logic state*	Logic state of digital output X114:8	*Active low*
	Active low	Active state of the output is low voltage.	0
187	*DO X114:9 logic state*	Logic state of digital output X114:9	*Active high*
	Active high	Active state of the output is high voltage.	1
200	*DO diagnostic pulse length*	Length of the diagnostic pulse for digital outputs	*1 ms*
	1 ms		1
201	*DO diagnostic pulse period*	Cycle time of the diagnostic pulse falling edge for digital outputs (time between diagnostic pulse falling edges)	59,000 ms
202	*DO X113:7 diag pulse on/of*	Diagnostic pulse of digital output X113:7 on or off	*On*
	On	Diagnostic pulse on	1
203	*DO X113:8 diag pulse on/off*	Diagnostic pulse of digital output X113:8 on or off	*On*
	On	Diagnostic pulse on	1
204	*DO X113:9 diag pulse on/off*	Diagnostic pulse of digital output X113:9 on or off	*On*
	On	Diagnostic pulse on	1
205	*DO X114:7 diag pulse on/off*	Diagnostic pulse of digital output X114:7 on or off	*On*
	On	Diagnostic pulse on	1
206	*DO X114:8 diag pulse on/off*	Diagnostic pulse of digital output X114:8 on or off	*On*
	On	Diagnostic pulse on	1
207	*DO X114:9 diag pulse on/off*	Diagnostic pulse of digital output X114:9 on or off	*Off*
	Off	Diagnostic pulse off	0

Cascade connection

If the FSO-11 module belongs to a cascaded safety function, connect the digital input also to the corresponding digital output. See section *Cascade* on page *38*.

No	Name/Value	Description	Example value
200	**Safety**	Safety parameters	
169	*M/F mode for cascade*	Master/follower mode of this FSO-11 module for both cascade channels separately	*A = follower, B = follower*
	A = follower, B = follower	This module is a follower on cascade connection A and a follower on cascade connection B.	0
176	*Cascade A*	For each FSO module in cascade A, the digital input connected to the safety function is also internally connected to the corresponding digital output of the module (digital input -> digital output). This resembles a master/follower connection. See section *Cascade* on page *38*.	*X113:1 & X114:1 -> X113:7 & X114:7*
	X113:1 & X114:1 -> X113:7 & X114:7	Redundant cascade X113:1 & X114:1 -> X113:7 & X114:7	1
177	*Cascade B*	For each FSO module in cascade B, the digital input connected to the safety function is also internally connected to the corresponding digital output of the module (digital input -> digital output). See section *Cascade* on page *38*.	*None*
	None	Not cascaded	0

Safety relays

If the FSO-11 module belongs to a cascaded safety function, connect the digital input also to the corresponding digital output.

No	Name/Value	Description	Example value
200	**Safety**	Safety parameters	
196	*Safety relay 1 output*	Output for the safety relay 1	*DO X113:8 & X114:8*
	DO X113:8 & X114:8	Redundant output X113:8 & X114:8	2
197	*Safety relay 1 feedback*	Feedback input of the safety relay 1	*DI X113:4*
	DI X113:4	Single input X113:4	8
198	*Safety relay 2 output*	Output for the safety relay 2	*None*
	None	No output connected	0
199	*Safety relay 2 feedback*	Feedback input of the safety relay 2	*None*
	None	No input connected	0

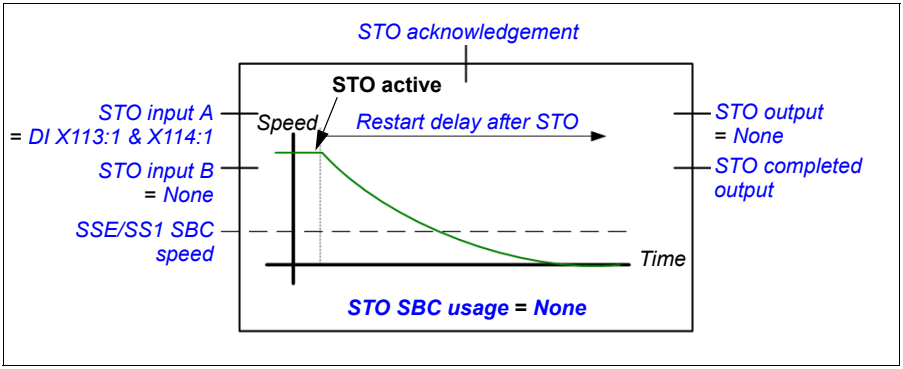
Configuring STO

How to configure STO

To configure the STO, set the FSO-11 parameters listed in the table below to appropriate values using the Drive composer pro PC tool. For more information on the STO function, see page *40*.

Example: The figure below and the Example value column in the table show an example of a simple STO function set-up:

- redundant emergency button connected to input
- automatic acknowledgement
- restart delay after STO 1000 ms
- no output connected
- no brake.



No	Name/Value	Description	Example value
200	**Safety**	Safety parameters	
7	*STO input A*	Digital input connected to the STO primary input	*DI X113:1 & X114:1*
	DI X113:1 & X114:1	Redundant input X113:1 & X114:1	1
8	*STO input B*	Digital input connected to the STO secondary input. Secondary input is mostly used for the cascade connection. See parameters *188 Cascade A* and *189 Cascade B*.	*None*
	None	No input connected	0
9	*Restart delay after STO*	Time after which the restart is allowed after the STO	1000 ms
11	*STO SBC usage*	Brake usage is always coupled with the STO. This parameter defines how.	*None*

No	Name/Value	Description	Example value
	None	No brake	0
15	*SSE/SS1 SBC speed*	Absolute speed below which the brake is activated while ramping. If the value is 0.0 rpm, this feature is not in use.	0.0 rpm
19	*STO acknowledgement*	STO acknowledgement method	*Automatic*
	Automatic	Automatic acknowledgement after the removal of requests	1
20	*STO output*	Digital output indicating activity of the STO	*None*
	None	No output connected	0
21	*STO completed output*	Digital output indicating completion of the STO. Active when the time defined by parameter 9 Restart delay after STO has elapsed after the STO request.	*None*
	None	No output connected	0

Configuring SBC

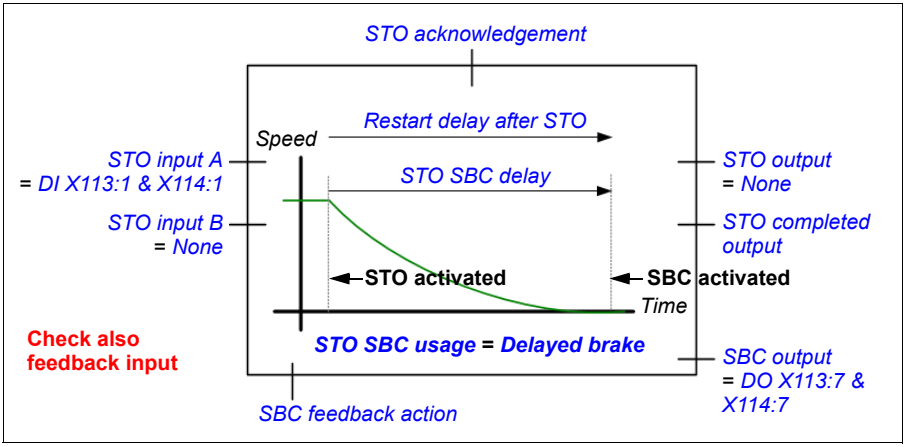
How to configure SBC after STO

To configure the SBC after the STO, set the FSO-11 parameters listed in the table below to appropriate values using the Drive composer pro PC tool. For more information on the SBC after the STO, see page *42*.

Example: The figure below and the Example value column in the table show an example of a set-up of the SBC after the STO:

- STO with brake
- redundant emergency button connected to input
- automatic acknowledgement
- restart delay after STO 1000 ms
- delayed brake with 900 ms delay
- brake connected to redundant output
- STO is activated if brake feedback fails.

Note: Maximum response time of the FSO-11 and drive combination is 100 ms.



No	Name/Value	Description	Example value
200	**Safety**	Safety parameters	
7	*STO input A*	Digital input connected to the STO primary input	*DI X113:1 & X114:1*
	DI X113:1 & X114:1	Redundant input X113:1 & X114:1	1

No	Name/Value	Description	Example value
8	*STO input B*	Digital input connected to the STO secondary input. Secondary input is mostly used for the cascade connection. See parameter *188 Cascade A*.	*None*
	None	No input connected	0
9	*Restart delay after STO*	Time after which the restart is allowed after the STO	1000 ms
11	*STO SBC usage*	Brake usage is always coupled with the STO. This parameter defines how.	*Delayed brake*
	Delayed brake	Time controlled brake	1
12	*STO SBC delay*	Brake usage delay relative to the STO. Negative value means that the brake is activated before STO activation. Note: Mechanical brake delays must be included in here.	900 ms
16	*SBC output*	Digital output connected to the SBC output (brake relays)	*DO X113:7 & X114:7*
	DO X113:7 & X114:7	Redundant output X113:7 & X114:7	1
18	*SBC feedback action*	Action taken when there is a problem on the SBC feedback	*STO*
	STO	STO activated	0
19	*STO acknowledgement*	STO acknowledgement method	*Automatic*
	Automatic	Automatic acknowledgement after the removal of requests	1
20	*STO output*	Digital output indicating activity of the STO	*None*
	None	No output connected	0
21	*STO completed output*	Digital output indicating completion of the STO. Active when the time defined by parameter 9 Restart delay after STO has elapsed after the STO request.	*None*
	None	No output connected	0

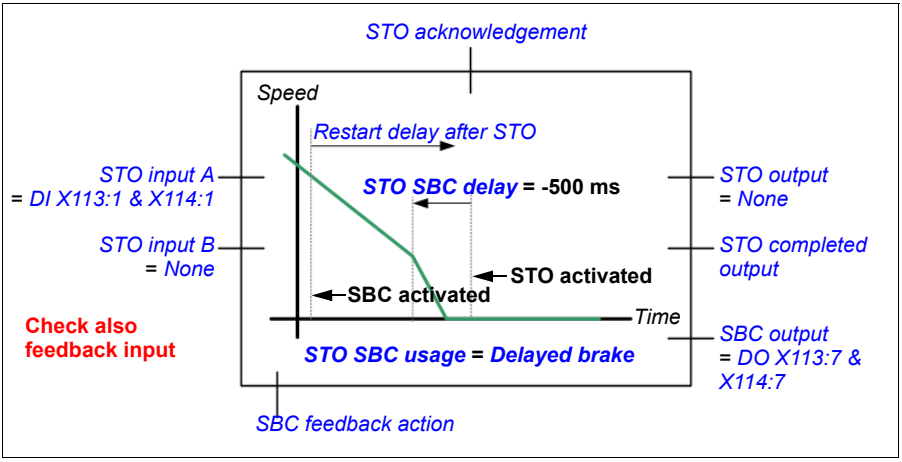
How to configure SBC before STO

To configure the SBC before the STO, set the FSO-11 parameters listed in the table below to appropriate values using the Drive composer pro PC tool. For more information on the SBC before the STO, see page 44.

Example: The figure below and the Example value column in the table show an example of a set-up of the SBC before the STO:

- STO with negative brake
- redundant emergency button connected to input
- automatic acknowledgement
- restart delay after STO 600 ms
- delayed brake with negative delay -500 ms
- brake connected to redundant output
- STO activated if brake feedback fails.

Note: Maximum response time of the FSO-11 and drive combination is 100 ms.



No	Name/Value	Description	Example value
200	**Safety**	Safety parameters	
7	*STO input A*	Digital input connected to the STO primary input	*DI X113:1 & X114:1*
	DI X113:1 & X114:1	Redundant input X113:1 & X114:1	1
8	*STO input B*	Digital input connected to the STO secondary input. Secondary input is mostly used for the cascade connection.	*None*
	None	No input connected	0

No	Name/Value	Description	Example value
9	*Restart delay after STO*	Time after which the restart is allowed after the STO	600 ms
11	*STO SBC usage*	Brake usage is always coupled with the STO. This parameter defines how.	*Delayed brake*
	Delayed brake	Time controlled brake	1
12	*STO SBC delay*	Brake usage delay relative to the STO. Negative value means that the brake is activated before STO activation. Note: Mechanical brake delays must be included in here.	-500 ms
16	*SBC output*	Digital output connected to the SBC output (brake relays)	*DO X113:7 & X114:7*
	DO X113:7 & X114:7	Redundant output X113:7 & X114:7	1
18	*SBC feedback action*	Action taken when there is a problem on the SBC feedback	*STO*
	STO	STO activated	0
19	*STO acknowledgement*	STO acknowledgement method	*Automatic*
	Automatic	Automatic acknowledgement after the removal of requests	1
20	*STO output*	Digital output indicating activity of the STO	*None*
	None	No output connected	0
21	*STO completed output*	Digital output indicating completion of the STO. Active when the time defined by parameter 9 Restart delay after STO has elapsed after the STO request.	*None*
	None	No output connected	0

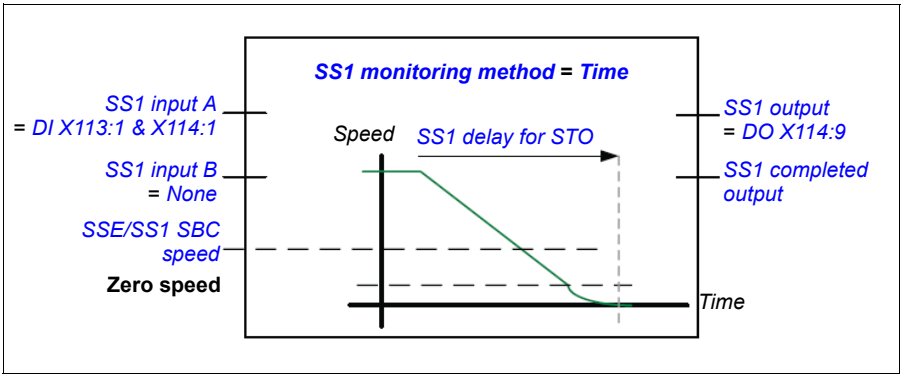
Configuring SS1

How to configure SS1 with time monitoring

To configure the SS1 with time monitoring, set the FSO-11 parameters listed in the table below to appropriate values using the Drive composer pro PC tool. For more information on the SS1 with time monitoring, see page *46*.

Example: The figure below and the Example value column in the table show an example of an SS1 with time monitoring set-up:

- SS1 with time monitored ramp
- redundant emergency button connected to input
- delay for activating STO 2000 ms
- single output connected
- speed activated brake not in use
- monitored ramp (SAR0).



No	Name/Value	Description	Example value
200	**Safety**	Safety parameters	
15	*SSE/SS1 SBC speed*	Absolute speed below which the brake is activated while ramping. If the value is 0.0 rpm, this feature is not in use.	0.0 rpm
35	*SS1 input A*	Digital input connected to the SS1 primary input	*DI X113:1 & X114:1*
	DI X113:1 & X114:1	Redundant input X113:1 & X114:1	1
36	*SS1 input B*	Digital input connected to the SS1 secondary input. Secondary input is mostly used for the cascade connection.	*None*
	None	No input connected	0
37	*SS1 monitoring method*	Method used for the SS1 monitoring	*Time*

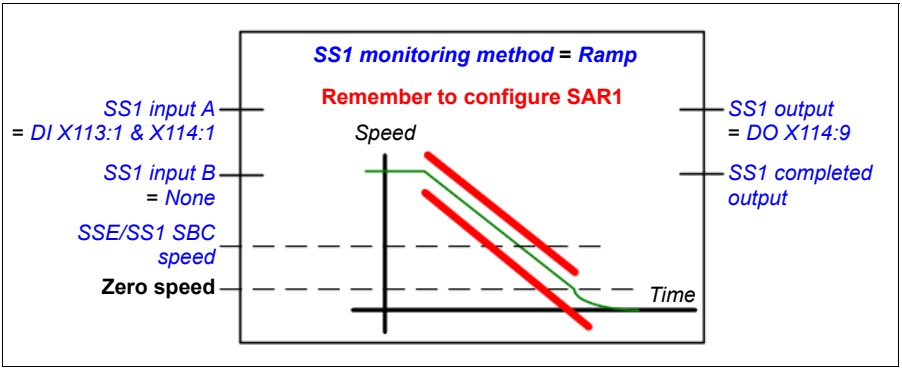
No	Name/Value	Description	Example value
	Time	Time monitoring	1
38	*SS1 delay for STO*	Time delay after which the STO is executed if time monitoring used.	2000 ms
39	*SS1 output*	Digital output indicating activity of the SS1	*DO X114:9*
	DO X114:9	Single output X114:9	9
40	*SS1 completed output*	Digital output indicating completion of the SS1. Active when the speed is below the speed defined by parameter 163 Zero speed without encoder and the STO is active.	*None*
	None	No output connected	0

How to configure SS1 with ramp monitoring

To configure the SS1 with ramp monitoring, set the FSO-11 parameters listed in the table below to appropriate values using the Drive composer pro PC tool. For more information on the SS1 with ramp monitoring, see page *48*.

Example: The figure below and the Example value column in the table show an example of an SS1 with ramp monitoring set-up:

- monitored ramp (SAR1; see section *How to configure SARn* on page *123*)
- redundant emergency button connected to input
- single output connected
- speed activated brake not in use.



No	Name/Value	Description	Example value
200	**Safety**	Safety parameters	
15	*SSE/SS1 SBC speed*	Absolute speed below which the brake is activated while ramping. If the value is 0.0 rpm, this feature is not in use.	0.0 rpm
35	*SS1 input A*	Digital input connected to the SS1 primary input	*DI X113:1 & X114:1*
	DI X113:1 & X114:1	Redundant input X113:1 & X114:1	1
36	*SS1 input B*	Digital input connected to the SS1 secondary input. Secondary input is mostly used for the cascade connection.	*None*
	None	No input connected	0
37	*SS1 monitoring method*	Method used for the SS1 monitoring	*Ramp*
	Ramp	Ramp monitoring	0
39	*SS1 output*	Digital output indicating activity of the SS1	*DO X114:9*
	DO X114:9	Single output X114:9	9

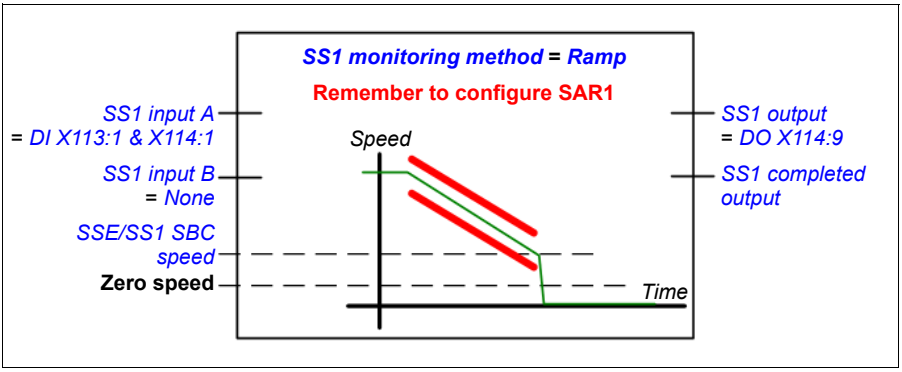
No	Name/Value	Description	Example value
40	*SS1 completed output*	Digital output indicating completion of the SS1. Active when the speed is below the speed defined by parameter 163 Zero speed without encoder and the STO is active.	*None*
	None	No output connected	0

How to configure SS1 with speed limit activated SBC

To configure the SS1 with speed limit activated SBC, set the FSO-11 parameters listed in the table below to appropriate values using the Drive composer pro PC tool. For more information on the SS1 with speed limit activated SBC, see page *49*.

Example: The figure below and the Example value column in the table show an example of an SS1 with speed limit activated SBC set-up:

- monitored ramp (SAR1; see section *How to configure SARn* on page *123*)
- redundant emergency button connected to input
- single output connected
- speed activated brake in use, speed below which the brake is activated 180.0 rpm.



No	Name/Value	Description	Example value
200	**Safety**	Safety parameters	
15	*SSE/SS1 SBC speed*	Absolute speed below which the brake is activated while ramping. If the value is 0.0 rpm, this feature is not in use.	180.0 rpm
35	*SS1 input A*	Digital input connected to the SS1 primary input	*DI X113:1 & X114:1*
	DI X113:1 & X114:1	Redundant input X113:1 & X114:1	1
36	*SS1 input B*	Digital input connected to the SS1 secondary input. Secondary input is mostly used for the cascade connection.	*None*
	None	No input connected	0
37	*SS1 monitoring method*	Method used for the SS1 monitoring	*Ramp*
	Ramp	Ramp monitoring	0
39	*SS1 output*	Digital output indicating activity of the SS1	*DO X114:9*
	DO X114:9	Single output X114:9	9

No	Name/Value	Description	Example value
40	*SS1 completed output*	Digital output indicating completion of the SS1. Active when the speed is below the speed defined by parameter 163 Zero speed without encoder and the STO is active.	*None*
	None	No output connected	0

Configuring SSE

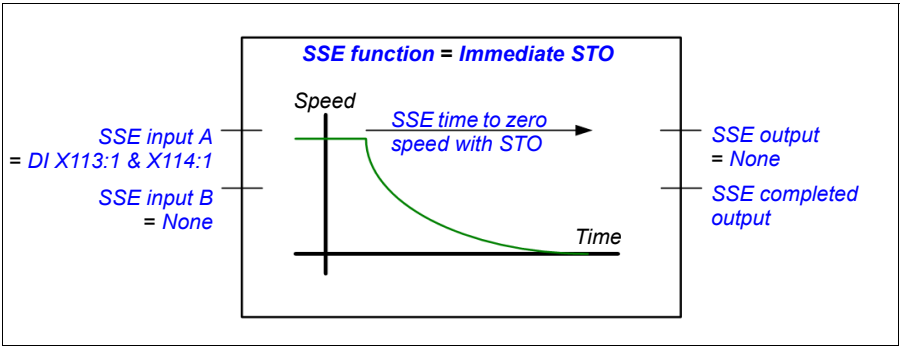
How to configure SSE

To configure the SSE, set the FSO-11 parameters listed in the table below to appropriate values using the Drive composer pro PC tool. For more information on the SSE function, see page *50*.

Example: The figure below and the Example value column in the table show an example of a simple SSE set-up:

- redundant emergency button connected to input
- no outputs connected
- STO related features configured in STO function.

Parameter *SSE time to zero speed with STO* must be configured to be the estimated time in which the motor coasts to a stop from the maximum speed.


SSE function = Immediate STO
Speed
SSE time to zero speed with STO
Time
SSE input A = DI X113:1 & X114:1
SSE input B = None
SSE output = None
SSE completed output

No	Name/Value	Description	Example value
200	**Safety**	Safety parameters	
24	*SSE time to zero speed with STO*	Time in which the acknowledgement is allowed after the SSE, when the SSE activates the STO (parameter 27 SSE function = Immediate STO)	5000 ms
25	*SSE input A*	Digital input connected to the SSE primary input	*DI X113:1 & X114:1*
	DI X113:1 & X114:1	Redundant input X113:1 & X114:1	1
26	*SSE input B*	Digital input connected to the SSE secondary input. Secondary input is mostly used for the cascade connection.	*None*
	None	No input connected	0
27	*SSE function*	Function activated by the SSE	*Immediate STO*
	Immediate STO	SSE activates the STO immediately	0

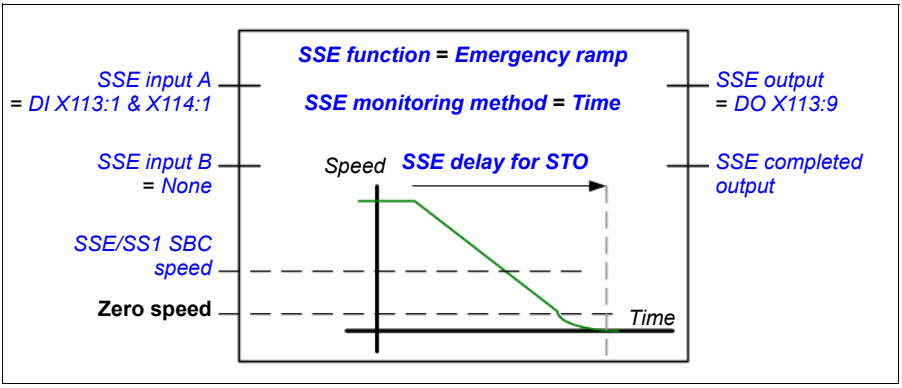
No	Name/Value	Description	Example value
30	*SSE output*	Digital output indicating activity of the SSE	*None*
	None	No output connected	0
31	*SSE completed output*	Digital output indicating completion of the SSE. Active when the speed is below the speed defined by parameter 163 Zero speed without encoder and the STO is active.	*None*
	None	No output connected	0

How to configure SSE with time monitoring

To configure the SSE with time monitoring, set the FSO-11 parameters listed in the table below to appropriate values using the Drive composer pro PC tool. For more information on the SSE with time monitoring, see page *52*.

Example: The figure below and the Example value column in the table show an example of an SSE with time monitoring set-up:

- time monitored ramp
- redundant emergency button connected to input
- delay for activating STO 2000 ms
- single output connected
- speed activated brake not in use.



No	Name/Value	Description	Example value
200	**Safety**	Safety parameters	
15	*SSE/SS1 SBC speed*	Absolute speed below which the brake is activated while ramping. If the value is 0.0 rpm, this feature is not in use..	0.0 rpm
25	*SSE input A*	Digital input connected to the SSE primary input	*DI X113:1 & X114:1*
	DI X113:1 & X114:1	Redundant input X113:1 & X114:1	1
26	*SSE input B*	Digital input connected to the SSE secondary input. Secondary input is mostly used for the cascade connection.	*None*
	None	No input connected	0
27	*SSE function*	Function activated by the SSE	*Emergency ramp*
	Emergency ramp	SSE activates the SS1 with emergency ramp	1
28	*SSE monitoring method*	Method used for the SSE monitoring	*Time*

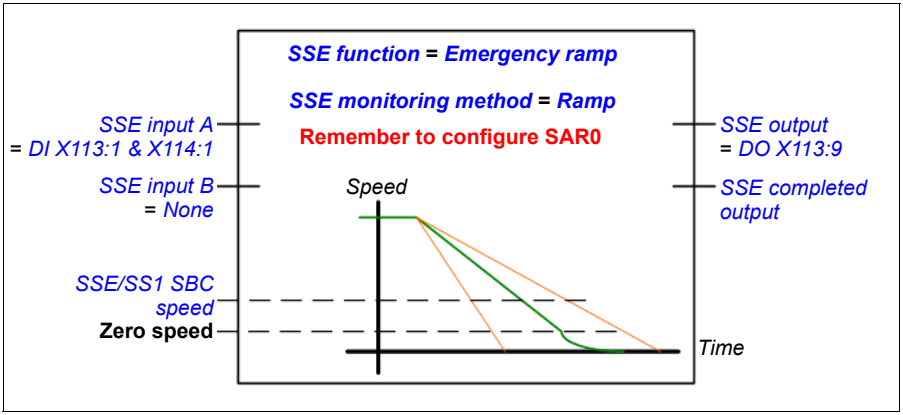
No	Name/Value	Description	Example value
	Time	Time monitoring	1
29	*SSE delay for STO*	Time delay after which the STO is executed if time monitoring used.	2000 ms
30	*SSE output*	Digital output indicating activity of the SSE	*DO X113:9*
	DO X113:9	Single output X113:9	6
30	*SSE completed output*	Digital output indicating completion of the SSE. Active when the speed is below the speed defined by parameter 163 Zero speed without encoder and the STO is active.	*None*
	None	No output connected	0

How to configure SSE with ramp monitoring

To configure the SSE with ramp monitoring, set the FSO-11 parameters listed in the table below to appropriate values using the Drive composer pro PC tool. For more information on the SSE with ramp monitoring, see page *53*.

Example: The figure below and the Example value column in the table show an example of an SSE with ramp monitoring set-up:

- monitored ramp (SAR0; see section *How to configure SARn* on page *123*)
- redundant emergency button connected to input
- single output connected
- speed activated brake not in use.



No	Name/Value	Description	Example value
200	**Safety**	Safety parameters	
15	*SSE/SS1 SBC speed*	Absolute speed below which the brake is activated while ramping. If the value is 0.0 rpm, this feature is not in use.	0.0 rpm
25	*SSE input A*	Digital input connected to the SSE primary input	*DI X113:1 & X114:1*
	DI X113:1 & X114:1	Redundant input X113:1 & X114:1	1
26	*SSE input B*	Digital input connected to the SSE secondary input. Secondary input is mostly used for the cascade connection.	*None*
	None	No input connected	0
27	*SSE function*	Function activated by the SSE	*Emergency ramp*
	Emergency ramp	SSE activates the SS1 with emergency ramp	1
28	*SSE monitoring method*	Method used for the SSE monitoring	*Ramp*
	Ramp	Ramp monitoring	0

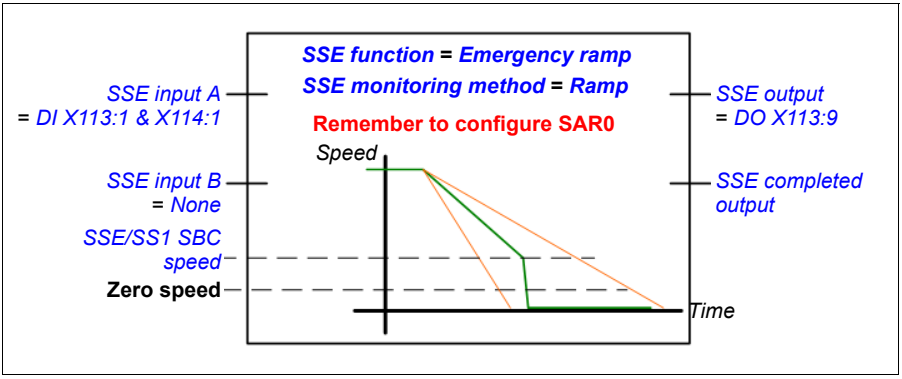
No	Name/Value	Description	Example value
30	*SSE output*	Digital output indicating activity of the SSE	*DO X113:9*
	DO X113:9	Single output X113:9	6
31	*SSE completed output*	Digital output indicating completion of the SSE. Active when the speed is below the speed defined by parameter 163 Zero speed without encoder and the STO is active.	*None*
	None	No output connected	0

How to configure SSE with speed limit activated SBC

To configure the SSE with speed limit activated SBC, set the FSO-11 parameters listed in the table below to appropriate values using the Drive composer pro PC tool. For more information on the SSE with speed limit activated SBC, see page *54*.

Example: The figure below and the Example value column in the table show an example of an SSE with speed limit activated SBC set-up:

- monitored ramp (SAR0; see section *How to configure SARn* on page *123*)
- redundant emergency button connected to input
- single output connected
- speed activated brake in use, speed below which the brake is activated is 240.0 rpm.



No	Name/Value	Description	Example value
200	**Safety**	Safety parameters	
15	*SSE/SS1 SBC speed*	Absolute speed below which the brake is activated while ramping. If the value is 0.0 rpm, this feature is not in use.	240.0 rpm
25	*SSE input A*	Digital input connected to the SSE primary input	*DI X113:1 & X114:1*
	DI X113:1 & X114:1	Redundant input X113:1 & X114:1	1
26	*SSE input B*	Digital input connected to the SSE secondary input. Secondary input is mostly used for the cascade connection.	*None*
	None	No input connected	0
27	*SSE function*	Function activated by the SSE	*Emergency ramp*
	Emergency ramp	SSE activates the SS1 with emergency ramp	1
28	*SSE monitoring method*	Method used for the SSE monitoring	*Ramp*
	Ramp	Ramp monitoring	0

No	Name/Value	Description	Example value
30	*SSE output*	Digital output indicating activity of the SSE	*DO X113:9*
	DO X113:9	Single output X113:9	6
31	*SSE completed output*	Digital output indicating completion of the SSE. Active when the speed is below the speed defined by parameter 163 Zero speed without encoder and the STO is active.	*None*
	None	No output connected	0

Configuring SAR

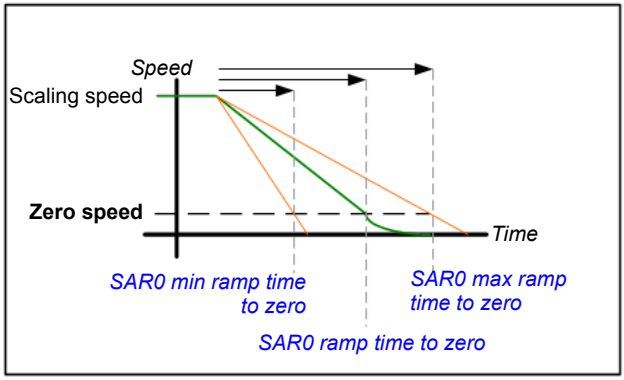
How to configure SARn

To configure the SARn (n = 0…1), set the FSO-11 parameters listed in the table below to appropriate values using the Drive composer pro PC tool.

Example: The figure below and the Example value column in the table show an example of a SAR0 set-up:

- SAR0
- ramp time from scaling speed to zero 800 ms
- minimum allowed ramp 500 ms
- maximum allowed ramp 1000 ms.

SAR0



No	Name/Value	Description	Example value
200	**Safety**	Safety parameters	
103	*SAR0 ramp time to zero*	Emergency ramp target time from the “scaling speed” to the zero speed	800 ms
104	*SAR0 min ramp time to zero*	Time to be subtracted from the target time to calculate the emergency ramp minimum time (-1 = not monitored)	500 ms
105	*SAR0 max ramp time to zero*	Time to be added to the target time to calculate the emergency ramp maximum time	1000 ms
106	*SAR1 ramp time to zero*	Stopping/SLS ramp target time from the “scaling speed“ to the zero speed	-
107	*SAR1 min ramp time to zero*	Time to be subtracted from the target time to calculate the Stopping/SLS ramp minimum time (-1 = not monitored)	-
108	*SAR1 max ramp time to zero*	Time to be added to the target time to calculate the Stopping/SLS ramp maximum time	-

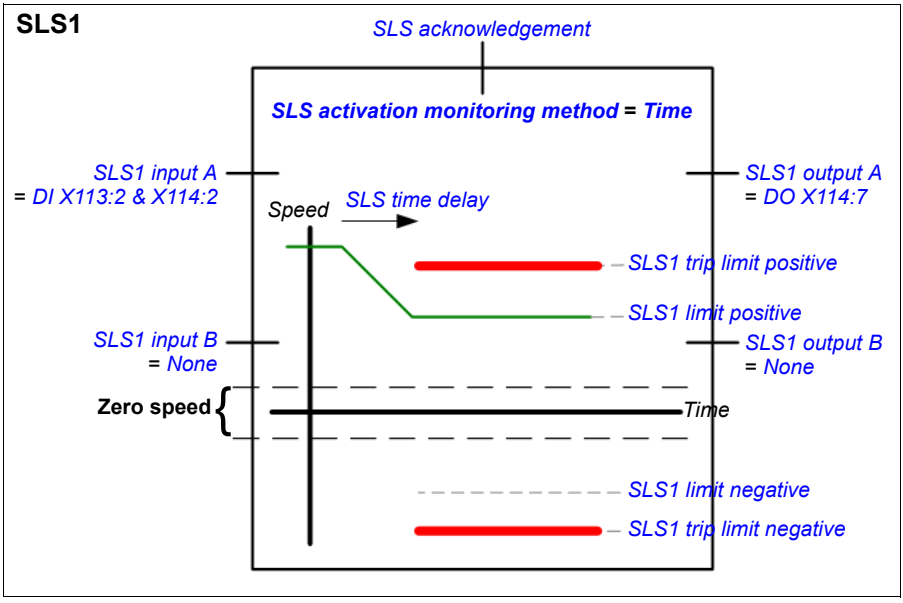
Configuring SLS

How to configure SLSn with time monitoring

To configure the SLSn (n = 1…4) with time monitoring, set the FSO-11 parameters listed in the table below to appropriate values using the Drive composer pro PC tool. For more information on the SLS function, see page *55*.

Example: The figure below and the Example value column in the table show an example of an SLS1 with time monitoring set-up:

- SLS1 (time monitored)
- redundant activation button connected to input
- single output connected
- SLS activation delay 2000 ms
- positive limits: target 1200.0 rpm, trip limit 1320.0 rpm
- negative limits: target -900.0 rpm, trip limit -1020.0 rpm
- automatic acknowledgement.



No	Name/Value	Description	Example value
200	**Safety**	Safety parameters	
60	*SLS1 input A*	Digital input connected to the SLS with limits 1 (primary input)	*DI X113:2 & X114:2*

No	Name/Value	Description	Example value
	DI X113:2 & X114:2	Redundant input X113:2 & X114:2	2
61	*SLS1 input B*	Digital input connected to the SLS with limits 1 (secondary input). Secondary input is mostly used for cascade connection (only SLS1 can be cascaded).	*None*
	None	No input connected	0
65	*SLS1 trip limit negative*	SLS1 negative speed limit tripping the drive	-1020.0 rpm
66	*SLS1 trip limit positive*	SLS1 positive speed limit tripping the drive	1320.0 rpm
67	*SLS1 limit negative*	SLS1 negative speed limit for the drive	-900.0 rpm
68	*SLS1 limit positive*	SLS1 positive speed limit for the drive	1200.0 rpm
81	*SLS activation monitoring method*	Method of SLS activation monitoring	*Time*
	Time	Time monitoring	1
82	*SLS time delay*	Delay for starting speed monitoring when time monitoring is used.	2000 ms
83	*SLS1 output A*	Digital output connected to the SLS1 primary output	*DO X114:7*
	DO X114:7	Single output X114:7	7
84	*SLS1 output B*	Digital output connected to the SLS1 secondary output. Secondary output is mostly used for cascade connection.	*None*
	None	No output connected	0
88	*SLS acknowledgement*	SLS acknowledgement method	*Automatic*
	Automatic	Automatic acknowledgement after the removal of requests	1

For SLSn (n = 2…4), instead of SLS1 parameters, configure the corresponding SLSn parameters listed in the table below as appropriate. The Example value column shows the parameter default values.

No	Name/Value	Description	Example value
200	**Safety**	Safety parameters	
62	*SLS2 input*	Digital input connected to the SLS with limits 2	*None*
	None	No input connected	0
63	*SLS3 input*	Digital input connected to the SLS with limits 3	*None*
	None	No input connected	0
64	*SLS4 input*	Digital input connected to the SLS with limits 4	*None*
	None	No input connectedd	0

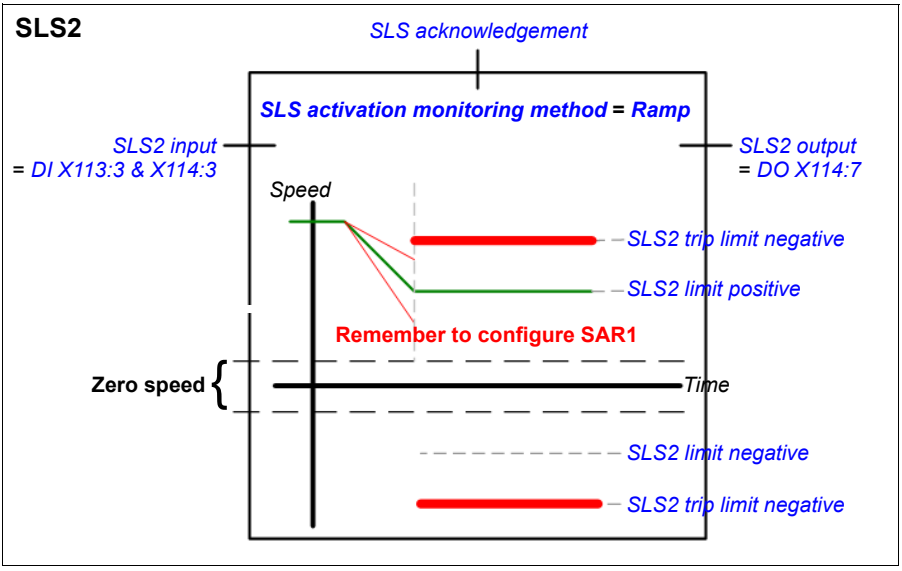
No	Name/Value	Description	Example value
69	*SLS2 trip limit negative*	SLS2 negative speed limit tripping the drive	-450.0 rpm
70	*SLS2 trip limit positive*	SLS2 positive speed limit tripping the drive	450.0 rpm
71	*SLS2 limit negative*	SLS2 negative speed limit for the drive	-400.0 rpm
72	*SLS2 limit positive*	SLS2 positive speed limit for the drive	-400.0 rpm
73	*SLS3 trip limit negative*	SLS3 negative speed limit tripping the drive	-650.0 rpm
74	*SLS3 trip limit positive*	SLS3 positive speed limit tripping the drive	650.0 rpm
75	*SLS3 limit negative*	SLS3 negative speed limit for the drive	-600.0 rpm
76	*SLS3 limit positive*	SLS3 positive speed limit for the drive	600.0 rpm
77	*SLS4 trip limit negative*	SLS4 negative speed limit tripping the drive	-1050.0 rpm
78	*SLS4 trip limit positive*	SLS4 positive speed limit tripping the drive	1050.0 rpm
79	*SLS4 limit negative*	SLS4 negative speed limit for the drive	-1000.0 rpm
80	*SLS4 limit positive*	SLS4 positive speed limit for the drive	1000.0 rpm
85	*SLS2 output*	Digital output connected to the SLS2	*None*
	None	No output connected	0
86	*SLS3 output*	Digital output connected to the SLS3	*None*
	None	No output connected	0
87	*SLS4 output*	Digital output connected to the SLS4	*None*
	None	No output connected	0

How to configure SLSn with ramp monitoring

To configure the SLSn (n = 1…4) with ramp monitoring, set the FSO-11 parameters listed in the table below to appropriate values using the Drive composer pro PC tool. For more information on the SLS function, see page *55*.

Example: The figure below and the Example value column in the table show an example of an SLS2 with ramp monitoring set-up:

- SLS2 (ramp monitored)
- redundant activation button connected to input
- single output connected
- positive limits: target 1200.0 rpm, trip limit 1320.0 rpm
- negative limits: target -900.0 rpm, trip limit -1020.0 rpm
- automatic acknowledgement.



No	Name/Value	Description	Example value
200	**Safety**	Safety parameters	
62	*SLS2 input*	Digital input connected to the SLS with limits 2	*DI X113:3 & X114:3*
	DI X113:3 & X114:3	Redundant input X113:3 & X114:3	3
69	*SLS2 trip limit negative*		-1020.0 rpm
70	*SLS2 trip limit positive*	SLS2 positive speed limit tripping the drive	1320.0 rpm

No	Name/Value	Description	Example value
71	*SLS2 limit negative*	SLS2 negative speed limit for the drive	-900.0 rpm
72	*SLS2 limit positive*	SLS2 positive speed limit for the drive	1200.0 rpm
81	*SLS activation monitoring method*	Method of SLS activation monitoring	*Ramp*
	Ramp	Ramp monitoring	0
85	*SLS2 output*	Digital output connected to the SLS2	*DO X114:7*
	DO X114:7	Single output X114:7	7
88	*SLS acknowledgement*	SLS acknowledgement method	*Automatic*
	Automatic	Automatic acknowledgement after the removal of requests	1

For SLSn (n = 1, 3…4), instead of SLS2 parameters, configure the corresponding SLSn parameters listed in the table below as appropriate. The Example value column shows the parameter default values.

No	Name/Value	Description	Example value
200	**Safety**	Safety parameters	
60	*SLS1 input A*	Digital input connected to the SLS with limits 1 (primary input)	*None*
	None	No input connected	0
61	*SLS1 input B*	Digital input connected to the SLS with limits 1 (secondary input). Secondary input is mostly used for cascade connection (only SLS1 can be cascaded).	*None*
	None	No input connected	0
63	*SLS3 input*	Digital input connected to the SLS with limits 3	*None*
	None	No input connected	0
64	*SLS4 input*	Digital input connected to the SLS with limits 4	*None*
	None	No input connectedd	0
65	*SLS1 trip limit negative*	SLS2 positive speed limit tripping the drive	-250.0 rpm
66	*SLS1 trip limit positive*	SLS2 positive speed limit tripping the drive	250.0 rpm
67	*SLS1 limit negative*	SLS2 negative speed limit for the drive	-200.0 rpm
68	*SLS1 limit positive*	SLS2 negative speed limit for the drive	200.0 rpm
73	*SLS3 trip limit negative*	SLS3 negative speed limit tripping the drive	-650.0 rpm

No	Name/Value	Description	Example value
74	*SLS3 trip limit positive*	SLS3 positive speed limit tripping the drive	650.0 rpm
75	*SLS3 limit negative*	SLS3 negative speed limit for the drive	-600.0 rpm
76	*SLS3 limit positive*	SLS3 positive speed limit for the drive	600.0 rpm
77	*SLS4 trip limit negative*	SLS4 negative speed limit tripping the drive	-1050.0 rpm
78	*SLS4 trip limit positive*	SLS4 positive speed limit tripping the drive	1050.0 rpm
79	*SLS4 limit negative*	SLS4 negative speed limit tripping the drive	-1000.0 rpm
80	*SLS4 limit positive*	SLS4 positive speed limit for the drive	1000.0 rpm
83	*SLS1 output A*	Digital output connected to the SLS1 primary output	*None*
	None	No output connected	0
84	*SLS1 output B*	Digital output connected to the SLS1 secondary output. Secondary output is mostly used for cascade connection.	*None*
	None	No output connected	0
86	*SLS3 output*	Digital output connected to the SLS3	*None*
	None	No output connected	0
87	*SLS4 output*	Digital output connected to the SLS4	*None*
	None	No output connected	0

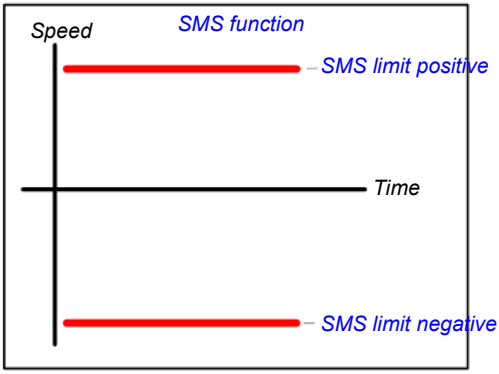
Configuring SMS

How to configure SMS

To configure the SMS, set the FSO-11 parameters listed in the table below to appropriate values using the Drive composer pro PC tool. For more information on the SMS function, see page 57.

Example: The figure below and the Example value column in the table show an example of an SMS set-up:

- SMS activated
- positive limit 1800.0 rpm
- negative limit -1200.0 rpm.



No	Name/Value	Description	Example value
200	**Safety**	Safety parameters	
92	*SMS function*	SMS activation	*Active*
	Active	Activates the SMS	1
93	*SMS limit negative*	Negative speed limit for the SMS	-1200.0 rpm
94	*SMS limit positive*	Positive speed limit for the SMS	1800.0 rpm

10

Start-up

Contents of this chapter

This chapter describes the general precautions to be taken before starting up the safety system for the first time.

Safety considerations

The start-up may only be carried out by a qualified electrician. The safety instructions must be followed during the start-up. See the drive and the safety component specific safety instructions in the individual product manuals.

WARNING! Until all the safety functionality is validated, the system must not be considered safe.

Checks

Before starting the system for the first time, make sure that

- the installation has been checked, according to the individual product checklists (drive, safety component) and the checklist provided in this document
- all necessary configuration steps have been completed
- all tools are cleared from the installation area to prevent short circuits and projectiles
- starting the system does not cause any danger.

For the start-up and validation of the STO, see chapter *Planning the electrical installation*, section *Implementing the Safe torque off function* in the drive *Hardware manual*.

11

Verification and validation

Contents of this chapter

This chapter describes verification and validation of the implemented safety functionality.

Verification and validation produce documented proof of the compliance of the implementation with specified safety requirements.

Further information can be found in *Technical guide No. 10 - Functional safety* (3AUA0000048753 [English]).

Verifying the achieved SIL/PL level

Verification of the functional safety system demonstrates and ensures that the implemented safety system meets the requirements specified for the system in the safety requirements specification phase.

The most convenient way to verify the required SIL/PL level reached with the implemented system is to use a specific safety calculator software.

Validation procedure

WARNING! Until all the safety functionality is validated, the system must not be considered safe.

The acceptance test must be performed to each safety function.

The acceptance test using the start-up checklist described below (see *Validation checklist for start-up*) must be performed:

- at initial start-up of the safety function
- after any changes related to the safety function (wiring, components, settings, etc.)
- after any maintenance work related to the safety function.

The acceptance test should include at least the following steps:

- having an acceptance test plan
- testing all commissioned functions for proper operation
- testing all used inputs for proper operation
- testing all used outputs for proper operation
- documenting all acceptance tests performed
- testing person signing and archiving the acceptance test report for further reference.

Validation checklist for start-up

Validation of the STO function

Note: The STO is the basic safety function and it has to be validated first.

The acceptance tests for the STO function of the drive are described in chapter *Planning the electrical installation* in the drive *Hardware manual*.

Validation of the other safety functions

Once the system is fully configured and wired for the safety functions, and the start-up safety check has been done, you must carry out the following functional test procedure for each configurated safety function:

1. Have the system at the Operational state when the safety function is requested.
2. Initiate an implemented safety function by requesting it with the designated trigger device.
3. Verify that the desired functionality takes place.
4. Ensure that the acknowledgement has been configurated as suitable for the application (for example manual/automatic acknowledgement).
5. Document the test results to the acceptance test report.
6. Sign and file the acceptance test report.

Validation of the SBC function

Follow the steps below to validate the SBC function with time controlled brake:

1. Ensure that parameter *STO SBC usage* is set to *Delayed brake* and parameter *STO SBC delay* is set correctly. (see section *How to configure SBC after STO* on page *105* and *How to configure SBC before STO* on page *107*).
2. Set parameter *SBC feedback action* in case of a problem on the SBC feedback (*STO* or nothing).
3. Ensure that the drive can be run and stopped freely.
4. Start the drive to the maximum motor speed allowed for the application.
5. Activate the STO function (for example disconnect the signal from the field device to the FSO-11 input).
6. Check that the SBC is activated after the motor has stopped when a positive *STO SBC delay* is used. In case of a negative *STO SBC delay*, ensure that the SBC is activated first and the STO after the delay has elapsed.
7. Check that the SBC feedback input is activated after the activation of the SBC output.
8. Set an acknowledgement (for example with the control panel), restart the drive and check that the brake will open and the motor runs normally.

Validation of the SSE and SS1 functions with time monitoring

Follow the steps below to validate the SSE and SS1 functions with time monitoring (each function separately):

1. Check the SSE (SS1) input connections from the field equipment to the FSO-11 against the circuit diagrams
2. Ensure that parameter *SSE monitoring method* is set to *Time* (parameter *SS1 monitoring method* is set to *Time*). See section *How to configure SSE with time monitoring* on page *117* (*How to configure SS1 with time monitoring* on page *109*).
3. Check that parameter *SSE delay for STO* (*SS1 delay for STO*) is set properly.
4. Start the drive and check that the motor can run at the maximum speed.
5. Activate the SSE or SS1 circuit (for example disconnect the signal from the field device to the FSO-11 input).
6. Check that the speed ramps down properly and the time monitoring is set correctly.
7. If the SBC is in use, check that the SBC is activated below the speed defined by parameter *SSE/SS1 SBC speed* (*SSE/SS1 SBC speed*).
8. Check that the STO is activated.
9. Set an acknowledgement (for example with the control panel), restart the drive and check that the motor runs normally.
10. If the motor can rotate in the reverse direction, repeat the test procedure for the reverse direction.

Validation of the SSE and SS1 functions with ramp monitoring

Follow the steps below to validate the SSE and SS1 functions with ramp monitoring (each function separately):

1. Check the SSE (SS1) input connections from the field equipment to the FSO-11 against the circuit diagrams.
2. Ensure that parameter *SSE monitoring method* is set to *Ramp* (parameter *SS1 monitoring method* is set to *Ramp*). See section *How to configure SSE with ramp monitoring* on page *119* (*How to configure SS1 with ramp monitoring* on page *111*).
3. Check that the SAR0 (SAR1) ramp times are set properly. See section *How to configure SARn* on page *123*.
4. Start the drive and check that the motor can run at the maximum speed.
5. Activate the SSE (SS1) circuit (for example disconnect the signal from the field device to the FSO-11 input).
6. Check that the speed ramps down properly and the SAR0 (SAR1) monitoring is set correctly.
7. If the SBC is in use, check that the SBC is activated below the speed defined by parameter *SSE/SS1 SBC speed* (*SSE/SS1 SBC speed*).
8. Check that the STO is activated.
9. Set an acknowledgement (for example with the control panel), restart the drive and check that the motor runs normally.
10. If the motor can rotate in the reverse direction, repeat the test procedure for the reverse direction.

Validation of the SLS function with time monitoring

Follow the steps below to validate the SLS function with time monitoring:

1. Check the SLS1 input connections from the field equipment to the FSO-11 against the circuit diagrams.
2. If the cascade connection is used, check the cascade connections and this checklist in all cascaded drives.
3. Ensure that parameter *SLS1 limit positive* is set properly and parameter *SLS1 limit negative* is set to zero (see section *How to configure SLSn with time monitoring* on page *124*).
4. Set parameters *SLS1 trip limit positive* and *SLS1 trip limit negative* to the correct values (less than the speed defined by parameter *SMS limit positive* and more positive than the speed defined by parameter *SMS limit negative*).
5. Set parameter *SLS time delay* to the correct value.
6. Select the correct SLS acknowledgement method (parameter *SLS acknowledgement*).
7. Start the drive and check that the motor can run at a higher speed than the speed defined by parameter *SLS1 limit positive*.
8. Activate the SLS1 monitoring (for example disconnect the signal from the field device to the FSO-11 input).
9. Check that the speed ramps to below the speed defined by parameter *SLS1 limit positive* before *SLS time delay* has elapsed.
10. If needed according to the risk assessment, test the application so that the SLS1 ramp monitoring trips the drive and other cascaded drives (that is, ramp down by SSE). Only the SLS1 can be cascaded.
11. If the SBC is in use, check that the SBC is activated below the speed defined by parameter *SSE/SS1 SBC speed*.
12. Check that the STO is activated.
13. Set an acknowledgement (for example with the control panel) if the automatic acknowledgement is not in use, restart the drive and check that the motor runs normally.
14. If the motor can rotate in the reverse direction, repeat the test procedure for the reverse direction.
15. Repeat the test with the other used SLS functions (only the SLS1 can be cascaded).

Validation of the SLS function with ramp monitoring

Follow the steps below to validate the SLS function with ramp monitoring:

1. Check the SLS1 input connections from the field equipment to the FSO-11 against the circuit diagrams.
2. If the cascade connection is used, check the cascade connections and this checklist in all cascaded drives.
3. Ensure that parameter *SLS1 limit positive* is set properly and parameter *SLS1 limit negative* is set to zero (see section *How to configure SLSn with ramp monitoring* on page *127*).
4. Set parameters *SLS1 trip limit positive* and *SLS1 trip limit negative* to the correct values (less than the speed defined by parameter *SMS limit positive* and more positive than the speed defined by parameter *SMS limit negative*)
5. Check that the SAR0 ramp times are set properly (see section *How to configure SARn* on page *123*).
6. Select the correct SLS acknowledgement method (parameter *SLS acknowledgement*).
7. Start the drive and check that the motor can run at a higher speed than the speed defined by parameter *SLS1 limit positive*.
8. Activate the SLS1 monitoring (for example disconnect the signal from the field device to the FSO-11 input).
9. Check that the speed ramps to below the speed defined by parameter *SLS1 limit positive* conform to the allowed rate between *SAR0 min ramp time to zero* and *SAR0 max ramp time to zero* (see section *How to configure SARn* on page *123*).
10. If needed according to the risk assessment, test the application so that the SLS1 time monitoring trips the drive and other cascaded drives (that is, ramp down by SSE). Only the SLS1 can be cascaded.
11. If the SBC is in use, check that the SBC is activated below the speed defined by parameter *SSE/SS1 SBC speed*.
12. Check that the STO is activated.
13. Set an acknowledgement (for example with the control panel) if the automatic acknowledgement is not in use, restart the drive and check that the motor runs normally.
14. If the motor can rotate in the reverse direction, repeat the test procedure for the reverse direction.
15. Repeat the test with the other used SLS functions (only the SLS1 can be cascaded).

Validation of the SMS function

Follow the steps below to validate the SMS function:

1. Ensure that the SMS is activated (see section *How to configure SMS* on page *130*).
2. Set parameter *SMS limit positive* to half of the value to be used in the application and parameter *SMS limit negative* to zero.
3. Ensure that the drive can be run and stopped freely.
4. Start up the drive and accelerate in the forward direction to a speed reference higher than the *SMS limit positive*.
5. The FSO-11 detects overspeed. As a result the STO is activated, and the drive displays a warning.
6. Set an acknowledgement (for example with the control panel), restart the drive and check that the motor runs normally.
7. If the motor can rotate in the reverse direction, set parameter *SMS limit positive* to zero and parameter *SMS limit negative* to half of the value to be used in the application and repeat the test procedure for the reverse direction.
8. Set parameters *SMS limit positive* and *SMS limit negative* to their proper values.
9. Repeat the test procedure as near as possible the maximum design speed of the machinery. This design speed must be same or higher than the maximum speed of the drive.
10. Restart the drive and check that the motor can run at the maximum and minimum speeds.

WARNING! If the SMS test is to be performed with the machinery coupled to the motor, make sure that the machinery is able to withstand the fast speed changes and the set maximum speed.

Authorized person

The acceptance test of a safety function must be carried out by an authorized person with expertise and knowledge of the safety function. The test report must be documented and signed by the authorized person.

Acceptance test reports

Signed acceptance test reports must be stored in the logbook of the machine. The report must include documentation of the start-up activities and test results, references to the failure reports and resolution of failures. Any new acceptance test performed due to changes or maintenance must also be logged in the logbook.

Note: It is always the responsibility of the machine builder to ensure that the functionality of all the required safety functions has been appropriately verified and validated.

WARNING! Until all the safety functionality is verified and working properly, the system must not be considered safe.

Proof test intervals during operation

Proof tests are intended to ensure that the safety integrity of a safety system is maintained continuously and does not deteriorate over time. Proof tests are often required for mechanical brakes, for example. Proof tests are used mainly for parts of the system that cannot be automatically diagnosed.

The proof test interval is the interval between two proof tests. When the proof test interval has elapsed, the safety system has to be tested and restored to an "as new condition". The proof test must also be part of the regular maintenance plan.

For some of the components (electronics), the proof test interval is the same as the expected life time of the system.

A specific safety calculator software can assist in determining the requirements for the proof tests.

Residual risks

The safety functions are used to reduce the recognized hazardous conditions. In spite of this, it is not always possible to eliminate all potential hazards. Therefore the warnings for the residual risks must be given to the operators.

12

Fault tracing

Contents of this chapter

This chapter describes the status LEDs and provides generic diagnostics and troubleshooting tips for FSO-11 related faults generated by the drive.

Status LEDs

The status LEDs are situated on the front of the FSO-11 module. The table below describes the status LED indications.

LED	LED off	LED lit and steady		LED blinking	
POWER	No power	Green	Power to the FSO-11 is on.	-	-
RUN	FSO-11 is in the Fault state, or Safe state (STO activated).	Green	FSO-11 is in the Operational or Safe state.	Green	FSO-11 is in the Configuration or Start-up state.
STATUS/FAULT	The drive is in normal operation, without active safety functions and no faults.	Green	A safety function is active.	Green	Request for a safety function has ended but it has not been acknowledged.
		Red	A fault or FSO-11 is in the Configuration state (RUN LED is blinking)	-	-
STO	The STO circuit is closed and the drive is in operation.	Green	The STO circuit is open.	-	-

FSO-11 related faults, warnings and events

The FSO-11 generates three types of events:

- Pure events, which are just informative data
- Warnings, which are shown to the user, even if there are faults
- Faults, which stop the drive and are shown to the user.

Auxiliary code

Faults, warnings and events have 32-bit auxiliary codes, which help in pinpointing the problem. For the moment, auxiliary codes are for ABB internal use only.

Faults and delayed faults

All faults are sent to the drive as warnings, and when the safe state is reached, the general fault is sent.

General fault

The FSO general fault stops the drive immediately. Normally this fault is sent to the drive after one of the warnings below, which are actually delayed faults.

Code (hex)	Fault	Cause	What to do
7A8B	FSO general fault	A general fault message from the FSO-11	See the warning log for more information.

Warnings (delayed faults)

Code (hex)	Fault	Cause	What to do
A7D1	FSO internal fault	Internal fault in the FSO-11 module	Replace the FSO-11 module. Contact your local ABB representative. See the Aux code for more details (for the moment, for ABB internal use only).
A7D2	FSO IO fault	Problems in the I/O cabling	Check the FSO-11 I/O cabling. See the Aux code for more details (for the moment, for ABB internal use only).
A7D3	FSO STO fault	Problems in the STO cabling or inside the drive	Check the FSO-11 STO cabling.
A7D4	FSO STO activation	FSO STO activated for external request, limit hit or normal operation.	See the Aux code for more details (for the moment, for ABB internal use only).
A7D5	FSO communication fault	Fault in FSO - drive control unit, VVSL, FEN or FIG communication	Check all connections. See the Aux code for more details (for the moment, for ABB internal use only).
A7D7	FSO configuration fault	Fault in FSO configuration	Check the FSO-11 configuration.

Code (hex)	Fault	Cause	What to do
A7D9	FSO encoderless fault	Speed estimate too large.	• Check the behavior of the driven load compared with the drive control parameter settings. • Check suitability of the drive train and the motor. • Adapt control parameters if gear play or torsional rigidity causes problems.
A7DA	FSO temperature	FSO temperature fault, usually over temperature	• Check ambient conditions. • Replace the FSO-11 module. Contact your local ABB representative.

Warnings

Code (hex)	Warning	Cause	What to do
A7D0	FSO warning	Warning from the FSO-11, for example: • transition to the Configuration state • acknowledgement button operated in a wrong way • external request ending in the STO (if configured as a warning) • safety function limit hit from the SLS (if configured as a warning).	See Aux code for more details (for the moment, for ABB internal use only).

Events

Code (hex)	Event	Cause	What to do
B790	FSO event	A pure event; not a fault or warning, for example: • external request ending in the STO (if configured as an event) • safety function limit hit from the SLS (if configured as an event).	See Aux code for more details (for the moment, for ABB internal use only).

For other fault and alarm messages generated by the drive, see chapter *Fault tracing* in the drive *Firmware manual*.

For factory reset, see section *FSO-11 module failure* on page *147*.

13

Maintenance

Contents of this chapter

This chapter explains replacement of the FSO-11 module in case of a module failure, reinstalling the FSO-11 module to another drive, updating the firmware of the drive where the FSO-11 is installed, factory reset, FSO-11 update and decommissioning as well as proof tests.

WARNING! Read and follow the instructions in chapter *Safety instructions* in the drive *Hardware manual*. Ignoring the instructions can cause physical injury or death, or damage to the equipment.

FSO-11 module failure

If the FSO-11 module fails to operate, you have to replace it with a new one; the module is not repairable.

Replacing the FSO-11 module

1. Stop the driven machinery and prevent an unexpected start-up.
2. Upload the FSO-11 parameters from the FSO-11 to the Drive composer pro PC tool.
3. Disconnect the supply with the supply disconnecting device.
4. Disconnect the auxiliary voltage supply to the FSO-11.
5. Remove the wiring and the FSO-11 module.
6. Mark clearly on the FSO-11 module that it is decommissioned.
7. Install the new FSO-11 module and wiring according to chapter *Installation* on

page 65.

8. Download the FSO-11 parameters from the Drive composer pro PC tool to the FSO-11 according to chapter *Configuration* on page 73.
9. Perform the start-up procedure according to chapter *Start-up* on page 131.
10. Perform the validation procedure for each safety function according to chapter *Verification and validation* on page 133.

    Note: The STO is the basic safety function and it has to be validated first. The acceptance tests for the STO function of the drive are described in chapter *Planning the electrical installation* in the drive *Hardware manual*.
11. Update the HW and SW versions of the new FSO-11 to the logbook of the driven machine.

Drive replacement

If you have to replace the drive where the FSO-11 is installed, for example because of a serious drive failure, follow the procedure below.

Reinstalling the FSO-11 module to another drive

1. Stop the driven machinery and prevent an unexpected start-up.
2. Do one of the following:
   a. Upload the FSO-11 parameters from the FSO-11 to the Drive composer pro PC tool.
   b. Make a backup of the drive. See the drive *Firmware manual*.
3. Disconnect the supply with the supply disconnecting device.
4. Disconnect the auxiliary voltage supply to the FSO-11.
5. Remove the wiring and the FSO-11 module.
6. Install the new drive. See the drive *Hardware manual*.
7. Install the FSO-11 module and wiring to the new drive according to chapter *Installation* on page 65.
8. Do one of the following (the same letter as in step 2.):
   a. Download the FSO-11 parameters from the Drive composer pro PC tool to the FSO-11 according to chapter *Configuration* on page 73.
   b. Restore the backup to the drive. See the drive *Firmware manual*.
3. Perform the start-up procedure according to chapter *Start-up* on page 131.
4. Perform the validation procedure for each safety function according to chapter *Verification and validation* on page 133.

Note: The STO is the basic safety function and it has to be validated first. The acceptance tests for the STO function of the drive are described in chapter *Planning the electrical installation* in the drive *Hardware manual*.

5. Update the HW and SW versions of the new drive to the logbook of the driven machine.

Drive firmware update

If you have to update the firmware of the drive where the FSO-11 is installed, follow the procedure below.

Updating the firmware of the drive where the FSO-11 is installed

1. Stop the driven machinery and prevent an unexpected start-up.
2. Do one of the following:
   a. Upload the FSO-11 parameters from the FSO-11 to the Drive composer pro PC tool.
   b. Make a backup of the drive. See the drive *Firmware manual*.
3. Update the firmware of the drive.
4. Do one of the following (the same letter as in step 2.):
   a. Download the FSO-11 parameters from the Drive composer pro PC tool to the FSO-11 according to chapter *Configuration* on page 73.
   b. Restore the backup to the drive. See the drive *Firmware manual*.
3. Perform the start-up procedure according to chapter *Start-up* on page 131.
4. Perform the validation procedure for each safety function according to chapter *Verification and validation* on page 133.

   Note: The STO is the basic safety function and it has to be validated first. The acceptance tests for the STO function of the drive are described in chapter *Planning the electrical installation* in the drive *Hardware manual*.
5. Update the HW and SW versions of the new drive to the logbook of the driven machine.

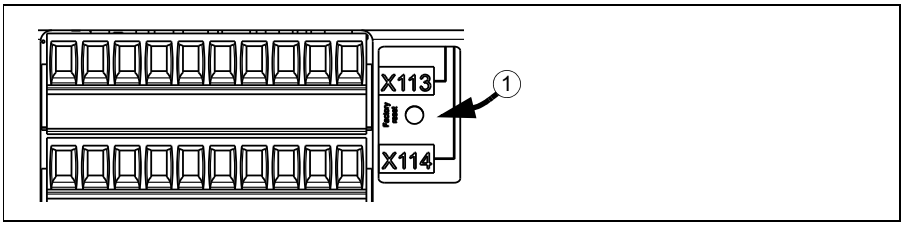
Factory reset

Do a factory reset if

- you forget the password
- you want to do the configuration again from scratch.

Note: The factory reset clears the configuration and takes the factory default values back in use. These default values are not the same as the pre-set values in a delivered FSO-11 and these default values are invalid for restart. The FSO-11 needs a full reconfiguration before it can be restarted.

1. Lift the Factory reset label to the right of the I/O terminals and push the button underneath with for example a pen until the LEDs start to blink (about 5 seconds). This returns the factory settings (parameters, including the password) to the FSO-11.



2. Reconfigure the safety functions with the Drive composer pro PC tool. Make sure that parameter *9 Restart delay after STO* is set to a proper value.
3. Specify a new password with the tool.

Update

After any changes in the safety application or the safety system configuration, you must perform the acceptance tests to verify that the safety functionality is maintained. See chapter *Verification and validation* on page *133*.

Proof tests

If periodic proof testing is necessary based on the safety calculations, you must include proof tests in the maintenance plan and perform them periodically. See also section *Proof test intervals during operation* on page *141*.

Decommissioning

When decommissioning the FSO-11, make sure that the safety of the machine is maintained until the decommissioning is complete. Mark clearly on the FSO-11 module that it is decommissioned.

14

Technical data

Contents of this chapter

This chapter contains the technical specifications of the FSO-11.

Electrical data

Supply voltage	+24 ± 3 V DC
Current consumption	Maximum 1000 mA
Inputs	4 redundant or 8 single, or combinations of redundant and single, 24 V DC NPN
Outputs	3 redundant or 6 single, or combinations of redundant and single, 24 V DC PNP

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Control connection data

Logic levels	“0” < 5 V, “1” > 15 V
Digital input impedance	4 kohm
Digital output drive capability	150 mA each, 700 mA total
Max. allowed cable length between the drive and the activation switch	250 m (820 ft)

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Terminal and lead-through data for the control cables

Conductor size						Tightening torque	
Solid or stranded		Stranded, ferrule without plastic sleeve		Stranded, ferrule with plastic sleeve			
Min/Max	Min/Max	Min/Max	Min/Max	Min/Max	Min/Max		
mm^2	AWG	mm^2	AWG	mm^2	AWG	N·m	lbf·in
0.14/1.5	26/16	0.25/1.5	23/16	0.25/0.5	23/21	0.24	2.1

Conductor size, two conductors with the same cross section								Tightening torque	
Solid		Stranded		Stranded, ferrules without plastic sleeve		Stranded, TWIN ferrules with plastic sleeve			
Min/Max	Min/Max	Min/Max	Min/Max	Min/Max	Min/Max	Min/Max	Min/Max		
mm^2	AWG	mm^2	AWG	mm^2	AWG	mm^2	AWG	N·m	lbf·in
0.08/0.5	28/21	0.08/0.75	28/19	0.25/0.34	23/22	0.5/0.5	21/21	0.24	2.1

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Degrees of protection

Degree of protection	IP20

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Size and weight

	mm	in	kg	lb
Length	100	3.94	-	-
Width	60	2.36	-	-
Depth (with wiring)	50	1.97	-	-
Weight	-	-	0.230	0.507

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Cooling

Cooling method	Dry clean air (natural convection)

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Speed estimation

Speed range	Allowed range depends on the used motor. Maximum range: (-18000…+18000 rpm)/(number of motor pole pairs).
Accuracy	Static situation: With nominal speed and torque ± 30 rpm. Dynamic situation: Depends on the torque. For example, without torque, the tripping limit is higher than the SLS trip limit parameter defines.

Ambient conditions

	Operation installed for stationary use	**Storage** in the protective package	**Transportation** in the protective package
Altitude	0…1000 m (0…3300 ft) above sea level, no derating required 1000…2000 m (3300…6600 ft) above sea level, air outside the module derated to -15…+49 °C (+5…+120 °F) 2000…4000 m (6600…13200 ft) above sea level, air outside the module derated to -15…+40 °C (+5…+104 °F)	-	-
Air temperature	-15…+55 °C (+5…+131 °F); +70 °C (+158 °F) inside the module	-40…+70 °C (-40…+158 °F)	-40…+70 °C (-40…+158 °F)
Relative humidity	5…95%, no condensation allowed	5…95%, no condensation allowed	5…95%, no condensation allowed

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Safety functionality

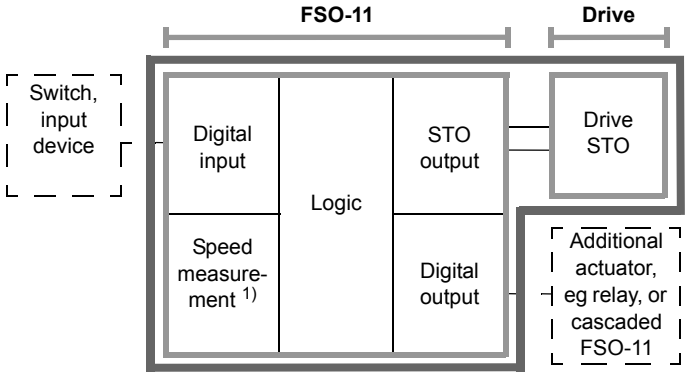
Stopping functions
STO Safe torque off
SBC Safe brake control
SS1 Safe speed 1
SSE Safe stop emergency
Speed-related functions
SLS Safely-limited speed
SMS Safe maximum speed
SAR Safe acceleration range - SAR is only used for deceleration with SS1, SSE and SLS

Safety data

General

To determine the SIL/PL capability of the whole safety function where FSO-11 is included, the failure rates (PFD/PFH_d) of all components implementing the safety function (see the figure on page *155*) must be added.

- **FSO-11 module with its subsystems**. The FSO-11 acts as the logic part in the safety function. Safety data for different subsystems are shown in section *Basic safety data* on page *156*. Safety data for some typical configurations of these subsystems are pre-calculated and shown in section *Safety data for some typical configurations* on page *157*.
- **Drive STO**. All safety functions implemented with the FSO-11 utilize the drive STO as the actuator. For the safety data, see the drive *Hardware manual*.
- **Sensors, input devices and possible additional actuators**. For the safety data, see the manufacturer's documentation.



The safety data of the FSO-11 and the drive is composed of the safety data of the subsystems used in the FSO-11 and the safety data of the drive STO.

Note 1: The Speed measurement subsystem of the FSO-11 is only included in those safety functions that measure the speed of a motor. For example the Prevention of unexpected start-up or the SSE with stop category 0 (drive coasts to a stop) do not use the speed measurement subsystem.

After calculating the total PFD/PFH_d for the safety function, it must be verified that the PFD/PFH_d of the safety function fulfills the requirement for the targeted SIL/PL.

Basic safety data

The FSO-11 data related to safety standards IEC 61508, EN 61800-5-2, EN ISO 13849-1 and EN 62061 are listed below for the different subsystems. Calculations are based on existing hardware, redundant function activation, STO and redundant indication, all in pulsed mode.

EN 61508	
SIL	up to 3

EN ISO 13849-1	
PL	up to e

EN 62061	
SILCL	3

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	1-channel DI, pulses	2-channel DI, pulses	1-channel DI, no pulses	2-channel DI, no pulses	Logic, 1-channel DI or DO, no pulses [1)]	Logic, other cases [1)]
PFH_d (h^{-1})	5.08E-10	1.19E-12	5.94E-09	1.15E-11	1.30E-08	6.79E-11
PFD_G (low demand)	4.71E-06	1.60E-08	5.20E-05	1.05E-07	9.52E-05	1.04E-05
SFF (%)	99.64	99.96	95.80	99.60	73.72	93.34
HFT	0	1	0	1	0	1
Cat.	2	3	1	3	1	3
$MTTF_d$ (a)	19228	19228	19228	19228	3762	3762

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Note 1: A logic subsystem is included in each safety function implemented with the FSO-11. If the safety function contains any 1-channel digital input or output of the FSO-11 with non-pulsed signals, the subsystem "Logic, 1-channel DI or DO, no pulses" must be used. Otherwise the subsystem "Logic, other cases" is used.

	1-channel DO, pulses	2-channel DO, pulses	1-channel DO, no pulses	2-channel DO, no pulses	STO output	Speed measure-ment
PFH_d (h^{-1})	8.82E-10	9.27E-12	4.58E-08	9.50E-11	1.06E-11	6.60E-09
PFD_G (low demand)	9.90E-06	1.25E-07	4.01E-04	8.41E-07	1.43E-07	2.98E-05
SFF (%)	99.69	99.84	83.74	98.38	99.81	99.00
HFT	0	1	0	1	1	1
Cat.	2	3	1	3	3	3
$MTTF_d$ (a)	2472	2472	2472	2472	2154	121

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Safety data for some typical configurations

The table below shows FSO-11 safety data for some typical configurations consisting of subsystems listed in the previous tables in section *Basic safety data* on page *156*.

Subsystems used in the safety function	PFH_d	PFD_G	SFF	HFT	SIL SILCL	MTTFd	DC	Cat.	PL
	h^{-1}		%			a	%		
Speed measurement 1-channel pulsed DI Logic STO output 1-channel pulsed output	8.07E-09	5.49E-05	99.02	0	**3**	105.85	98.64	2	**d**
1-channel pulsed DI Logic STO output 1-channel pulsed output	1.47E-09	2.51E-05	99.30	0	**3**	842.77	96.14	2	**d**
Speed measurement 1-channel non-pulsed DI Logic STO output 1-channel non-pulsed output	7.14E-08	5.78E-04	98.46	0	**2**	105.85	93.98	1	**c**
1-channel non-pulsed DI Logic STO output 1-channel non-pulsed output	6.48E-08	5.48E-04	92.56	0	**2**	842.77	51.80	1	**c**
Speed measurement 2-channel pulsed DI Logic STO output 2-channel pulsed output	6.69E-09	4.04E-05	99.03	1	**3**	105.85	98.72	3	**e**
2-channel pulsed DI Logic STO output 2-channel pulsed output	8.90E-11	1.06E-05	99.42	1	**3**	842.77	96.78	3	**e**
Speed measurement 2-channel non-pulsed DI Logic STO output 2-channel non-pulsed output	6.79E-09	4.12E-05	98.99	1	**3**	105.85	98.29	3	**e**
2-channel non-pulsed DI Logic STO output 2-channel non-pulsed output	1.85E-10	1.14E-05	98.80	1	**3**	842.77	93.37	3	**e**

Life time

FSO-11 life time	20 years

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Response times

Safety function response time	Maximum response time of the FSO-11 and drive combination is 100 ms. **Note:** Parameterable delays can change the response time.
FSO-11 response time • **from an FSO-11 input to the drive STO activation** • **from an FSO-11 input to an FSO-11 digital output activation**	 Maximum 50 ms Maximum 35 ms
Cascade response time • **from the cascade input to the cascade output activation** • **from the cascade input to the function activation**	 Maximum 35 ms Maximum 35 ms If the STO is cascaded, the worst case maximum time when the last FSO-11 has activated the STO is n · 35 ms where n is the number of cascaded FSO-11 modules.

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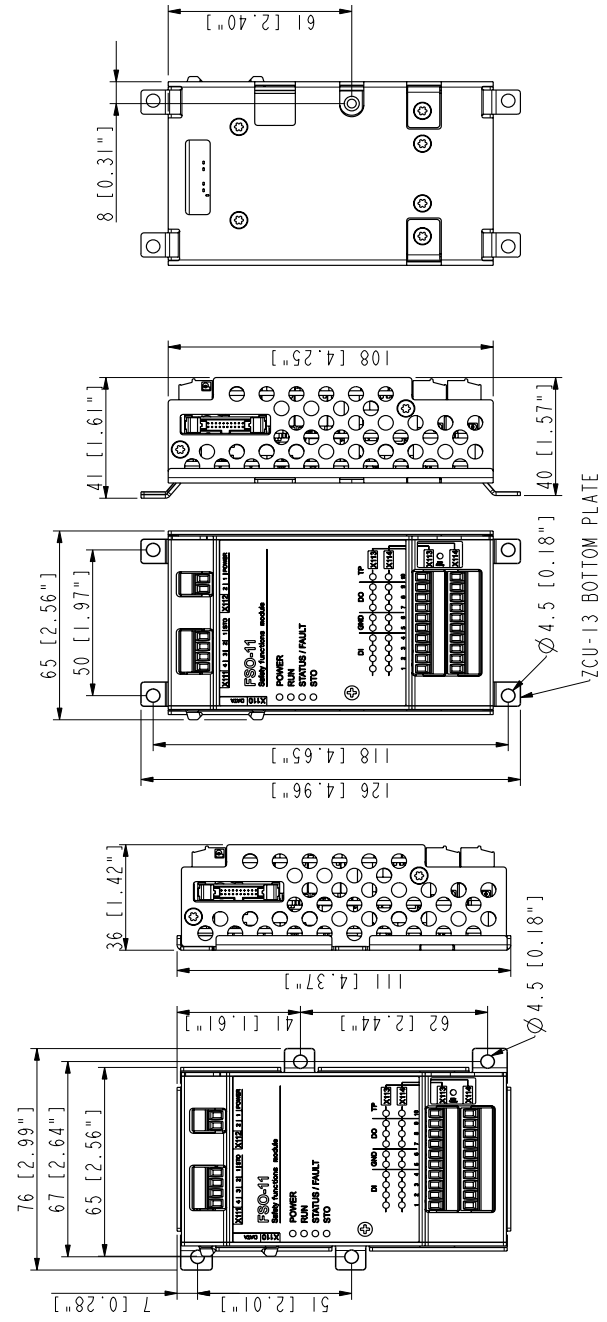
Dimension drawings

The dimension drawings of the FSO-11 module with two different bottom plates for different drive control unit types are shown below. The dimensions are given in millimeters and [inches].

FSO-11


61 [2.40"]
8 [0.31"]
108 [4.25"]
41 [1.61"]
40 [1.57"]
65 [2.56"]
50 [1.97"]
Ø 4.5 [0.18"]
ZCU-13 BOTTOM PLATE
118 [4.65"]
126 [4.96"]
36 [1.42"]
111 [4.37"]
Ø 4.5 [0.18"]
41 [1.61"]
62 [2.44"]
76 [2.99"]
67 [2.64"]
65 [2.56"]
7 [0.28"]
51 [2.01"]
FSO-11
Safety functions module
POWER
RUN
STATUS / FAULT
STO

Further information

Product and service inquiries

Address any inquiries about the product to your local ABB representative, quoting the type designation and serial number of the unit in question. A listing of ABB sales, support and service contacts can be found by navigating to www.abb.com/drives and selecting *Sales, Support and Service network*.

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